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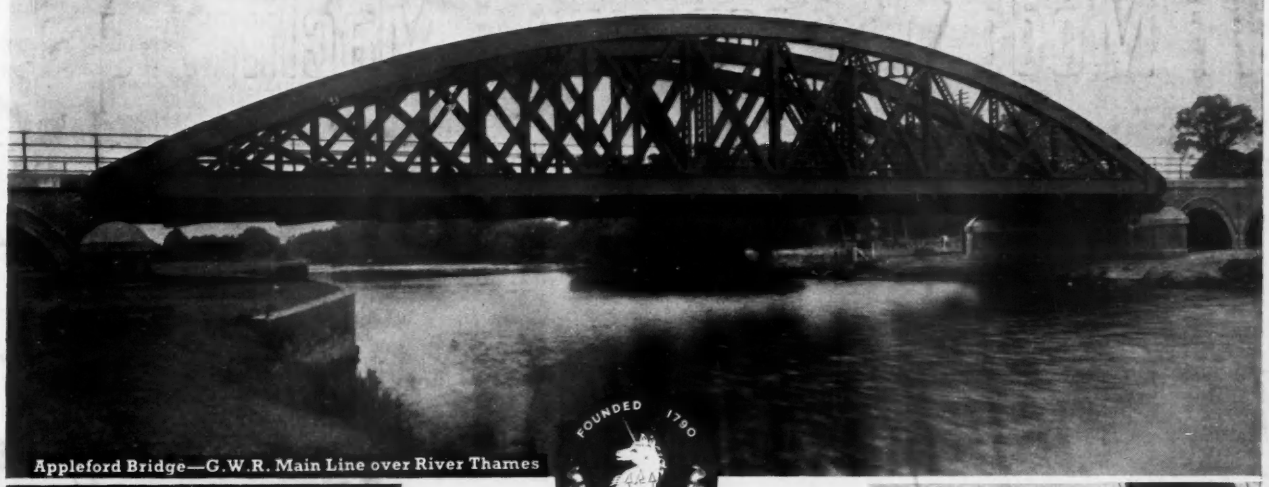

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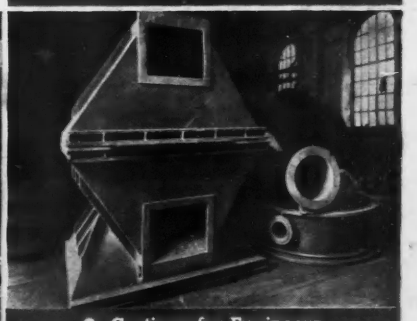

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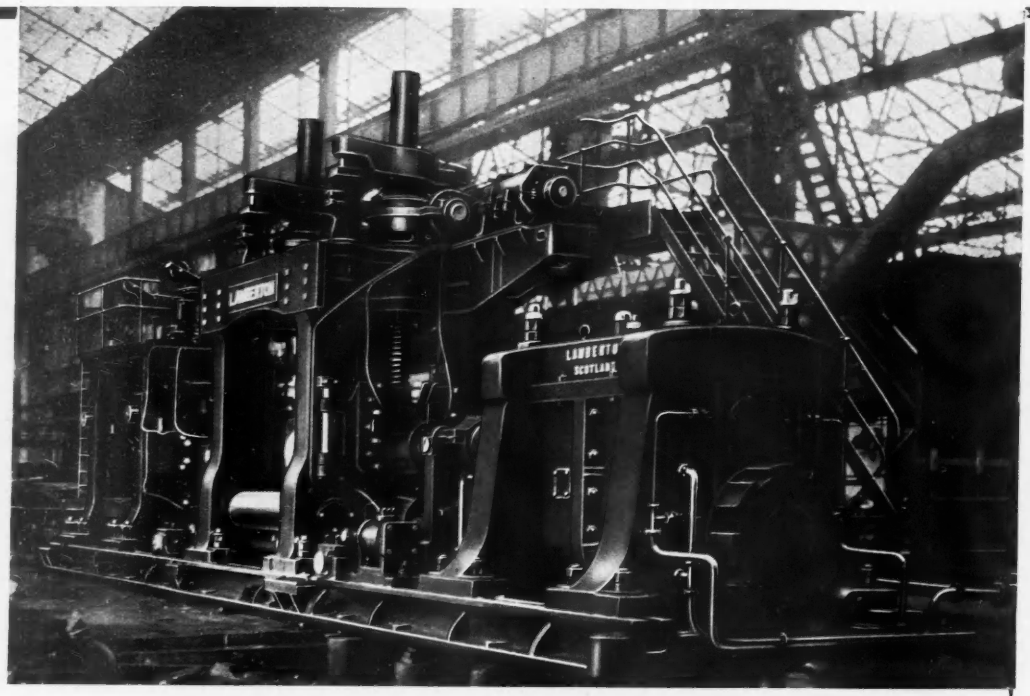

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The "Thetis" Inquiry

THE evidence of Lieut. Coltart was continued on Wednesday, July 12th, before the "Thetis" Tribunal, when more questions were put with regard to the dive of the submarine and the messages sent and received by Captain Godfrey, the master of the "Grebecock," the tug accompanying the "Thetis." On Thursday staff officers from Portsmouth and Plymouth spoke of the anxiety which was felt when no surfacing signal was received from the ship, and the delay in receiving Lieut. Coltart's telegram asking for the length of duration of the dive—which later evidence showed was not marked "Priority," and was delivered by messenger—was revealed. Evidence was also given as to the reliability of the smoke candles supplied to the "Thetis." On Friday and on Monday the evidence given dealt principally with the efforts to salve the ship when the stern was sighted above water. Commander Hart, the salvage officer of the Mersey Docks and Harbour Board, described the work done by the salvage ship "Vigilant" and the other vessels. The first impression formed was that the men inside were happy and were expecting to escape by means of the Davis apparatus. As time went on the working of the escape apparatus was doubted, and efforts against time were made by Mr. Charles Brock, the "wreck master," to remove a manhole cover by climbing on to the stern of the submarine. As an escape of air at high pressure occurred when the bolts were slackened off, they were screwed down again to await further instructions. Further work, it was stated, was prevented by the submarine heeling over, but an effort was made, rather against Captain Hart's judgment, to raise the stern further out of the water by placing tugs ahead of the "Vigilant," and pulling her up into the tide. Unfortunately, while this was being done the hull began to swing round, the original wire rope parted, and the "Thetis" again sank. On Tuesday evidence was taken from Mr. Frederick Orton, the diver who made the first descent. He said that he found wire rope which might have come from one of the marker buoys entangled around the conning tower. In his opinion, there would have been no difficulty in taking down an air pipe and fitting it to the gun recuperator valve. It was not possible for a diver to drill a hole in the hull 4ft. below the water, owing to the tides. Further evidence was given on the policy with regard to submarines by Captain Ruck-Keene, commanding the First Submarine Flotilla in the Mediterranean.

A Steel Trade Agreement

IT was officially announced last week that terms had been agreed upon between the Barrow Hæmatite Steel Company, Ltd., of Barrow-in-Furness, and Colvilles, Ltd., of Glasgow, by which, as part of an exchange of products manufactured by each company, the Barrow company will cease to operate its heavy and merchant mills for a period of ten years from January 1st, 1940, but will retain and continue to operate its mines, blast-furnaces, and hoop and bar mills. From this announcement it would appear likely that business in all the heavy steel products, such as rails and fishplates and heavy quality steels, for which Barrow has been famed for close upon half a century, will from the beginning of next year be transferred to the works of Colvilles in the West of Scotland, which are well equipped for turning out large quantities of rails and fish-plates. Presumably Colvilles will supply the necessary billets to the Barrow company for use in its mills, whilst hæmatite pig iron, which is a speciality of the Barrow furnaces, will be purchased in the coming years in large quantities by the Colville works. The closing of the Barrow bar mills should mean increased business for the Scottish steel industry. The Barrow Hæmatite Steel Company which was registered in 1864 owns blast-furnaces, steel works, and rolling mills at Barrow-in-Furness, and hæmatite iron ore mines in Barrow, Lancashire, and Cumberland. It is expected that with the cessation next year of the production of heavy steel, the company will be able to devote increased attention to the development of its mining and pig iron producing activities, and the manufacture of hoops and bars.

A New Post Office Cable Ship

IT is officially announced that the Post Office has placed an order with Swan, Hunter and Wigham Richardson, Ltd., of Wallsend-on-Tyne, for a new cable ship, which we understand will be built at the firm's Neptune Yard. It will be larger than the two cable ships "Alert" and "Monarch," which were constructed by the same firm in 1918 and 1916 respectively. The new ship is to be called the "Aerial," and will have a length of 250ft., with a beam of 35ft., and a measurement of about 1470 gross tons. She will be propelled by a twin-screw arrangement of triple-expansion steam engines, and her speed will be 13 knots. The fuel to be carried will give her a radius of action without refuelling of 4500 nautical miles. Although she is only 12ft. longer than the "Monarch," her speed will be 3 knots faster, and her capacity for carrying cables 60 per cent. larger. In designing her cable tanks, particular care has been taken to provide for the easy picking up or paying out of cable, and its transfer from one tank to another. The ship's complement will consist of about sixty-seven officers and men, and special attention has been made for the accommodation of the officers and crew. In addition to excellent accommodation for the deck and engineer officers, the petty officers and senior ratings will have single and two-berth cabins, and cabins will be provided for the seamen. The "Aerial" is to be armed for defence against aircraft and submarines, and both high-angle and low-angle guns are to be carried, the crew being trained in the use of these weapons by the Admiralty. The auxiliary equipment includes a balanced rudder, giving quick manœuvring, and the latest navigation instruments will be carried, including an echo sounder, a submerged log, a large range finder, and a wireless direction finder, in addition to the usual wireless telegraphy and telephony installation. In order to ensure that sufficient fresh food can be carried for any normal voyage, there will be cold storage space and a refrigerating plant. The new ship will carry a large number of small boats, and a special feature of the hull design is the large clear space which is to be left at the forward end of the deck, with a view to facilitating the carrying out of cable-repairing operations.

Railways Emergency Plans

ACCORDING to an official statement which was issued by the British railways on Monday, July 17th, in the event of an emergency occurring, the railways of this country will be ready to take their full share in the enormous demands which will be made upon their services and equipment. As public utility undertakings, the railway companies are embarking upon extensive air-raid precautions schemes in order to secure the protection of their staff against aerial attacks. Instruction is being given and instructional trains have been constructed equipped with decontamination chambers which will form useful mobile emergency units. Recognising the vital nature of railway transport to the country's defences, the Government has authorised the railway companies to carry out special works of a protective nature. These include, in addition to substantial structural alterations to railway properties, protection to signal men and men at work, protective clothing being provided for the essential staffs. In co-operation with the Government Departments, the railways are preparing their stations, trains, and premises for the necessary black-out of lighting which may be required. Much experimental work has already been undertaken, both in railway yards and at passenger stations, and in connection with the hooding of electric signal lights, and the obscuring of glare from locomotive fire-boxes. With the Post Office authorities steps have been taken to arrange alternative railway telephone circuits, both for carrying out railway work and rapidly disseminating air-raid warnings and information. Considerable work has been done in accumulating at strategic points stocks of vital materials, such as sleepers, timbers, bridge girders, rails, electrical equipment, locomotive spare parts, and track materials. New emergency trains are being built, equipped with large travelling cranes of the latest pattern, to augment the equipment which the railways already possess. Locomotives of non-standard types, which are serviceable but which under modern standardisation schemes would otherwise have been scrapped, are being preserved to ensure an adequate supply of engines being available to meet the requirements of an emergency. In connection with evacuation, detailed arrangements have been completed for the rapid movement of 4,000,000 people from the industrial areas by special trains and some 1200 de-training stations have been selected. During an emergency the evacuation arrangements and the extensive movements of His Majesty's Forces and their equipment would have priority, and public announcements would be made as to the passenger and freight services which would be maintained.

Trade in the British Empire

THE Fifteenth Congress of the Federation of Chambers of Commerce of the British Empire took place at the Guildhall on Monday, July 17th, under the presidency of Lord Dudley. Messages were received from the King and the Prime Minister, wishing success to the Congress, and its efforts to promote the trade and commerce of the Empire. The Congress was opened by Sir Thomas Inskip, the Secretary for the Dominions, who stated that in spite of the diminishing trade with countries under economic nationalism, trade within the Empire had increased. He referred to the redistribution of the people of the Empire and migration schemes, and said that although the United Kingdom could stimulate and finance migration, there could be no large-scale movement without the co-operation of the Dominions and the willingness of the people. In his Presidential Address Lord Dudley commented on the unfortunate position of the Crown Colonies with regard to triangular trade and exchange restrictions. He said that there were 200 payment and clearing agreements in the world, and that they were a serious handicap on the trade of the Colonies which exported to one country and imported from another. Efforts needed to be made to improve the channels and strengthen the commercial communications of the Empire. The development of power production was so recent, he said, that we were still perhaps tempted to concentrate our attention on the development of production, while failing to emphasise sufficiently the importance of planning consumption. Production would be immensely increased if effective demand could be increased. How many, Lord Dudley asked, of the world's problems would be automatically solved, and how many international tensions eased if the acerbity of competition for available markets could be lessened by a sudden increase in the absorptive capacity of those markets? The predominent problem of last century was to increase production, and he submitted that to increase consumption should be the predominant problem in this. Resolutions were passed calling upon the Home and Empire Governments to discuss ways and means for migration schemes designed to secure a balanced distribution of population within the Empire.

Salvage of the "Thetis" and "Squalus"

TOWARDS the end of last week the salvage operations on the sunken submarine H.M.S. "Thetis" were resumed by the Liverpool and Glasgow Salvage Association in Liverpool Bay. With the coming of better weather and the passing of the earlier heavy south-westerly gales, the "Zelo" was again moored over the sunken vessel. In an official notice issued on Tuesday, it was stated that the divers had roved the two new messenger wires under the forward and after ends of the keel of the submarine. On Tuesday a beginning was made with the placing of the specially made 9in. lifting wires below the hull, and with the continuance of fine weather it was reported on Wednesday that one lifting wire had been placed under the propeller shaft, and that one lifting wire had also been passed under the keel forward of the conning tower. Some fouled reeving wires were cleared, and work is progressing satisfactorily with regard to the placing of the other lifting wires. The salvage operations on the American submarine "Squalus" have received a check. On Thursday, July 13th, the bow of the ship with the two forward pontoons filled with compressed air broke the surface suddenly and shot into the air. The two forward pontoons and two aft pontoons then broke loose and the submarine again sank to the bottom.

Railway Accidents in 1938

THE report to the Minister of Transport of the Chief Inspecting Officer of Railways upon the accidents which occurred on the railways of Great Britain during the year 1938 was published by the Stationery Office on Friday, July 14th. It shows that last year the liability among passengers to casualty in railway accidents was one killed in every 156 millions carried, and one injured in over 3 millions. With regard to railway servants, the passenger and freight train-miles worked were about 65 millions per fatality and 7 millions per injury. Casualties at public road level crossings, including killed and injured, amounted roughly to one per 100 crossings. In train and movement accidents combined, the casualties among passengers, railway servants, and other persons totalled 321 killed and 8364 injured. These figures compare with 340 killed and 9552 injured for the previous year, and with annual averages of 308 and 7132 for the period 1930–34. Casualties caused by falling out of carriages were slightly above the annual average. With regard to public road crossings, of which there are some 4560, it is stated that the risk of accident is negligible compared with other risks of the road, but a higher standard of care is required on the part of users of the 22,650 occupation crossings throughout the country. The report concludes with a reference to the high standard of safety which generally prevailed throughout the year under review, but attention is drawn to the fact that out of 195 fatalities among employees in movement accidents, 125 men were killed when working, walking, or standing on the permanent way. The majority of these accidents, it is pointed out, were caused by misadventure and lack of caution, and reference is made to the improvement which should result from the closest co-operation by all concerned in the application of certain preventive arrangements.

Time of Discharge of High-Pressure Gases

By E. W. GEYER, B.Sc., Ph.D.*

IN a previous article† the author discussed the problem of determining the available energy of high-pressure gases discharged through nozzles from a vessel into which no flow occurs. It is now proposed to deal with the question of the time taken for the gases to drop from an initial pressure p_1 to any lower pressure p_2.

Consider a vessel of volume V ft.³ containing gas at the absolute pressure p_1 and absolute temperature T_1 and let the corresponding specific volume be v_1. Due to the escape of gas through a nozzle, say, the pressure and generally the temperature drop to the lower values p_2 and T_2 for which the corresponding specific volume is v_2. At any intermediate instant let the pressure, temperature, and specific volume be p, T, and v.

The weight discharged in time dt is

$$dW=-V\,d\left(\frac{1}{v}\right)=-V\,d\rho \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where ρ is the density of the gas.

The instantaneous rate of mass discharge is given by

$$W=C_d\,A\sqrt{2g\,\frac{\gamma}{\gamma-1}\,\frac{p}{v}\left[\left(\frac{p_o}{p}\right)^{\frac{2}{\gamma}}-\left(\frac{p_o}{p}\right)^{\frac{\gamma+1}{\gamma}}\right]} \quad (2)$$

where C_d is the coefficient of discharge of the nozzle,

A is the area of the nozzle,

γ is the adiabatic expansion index,

p_o is the pressure at the immediate nozzle exit.

It should be noted that p_o will be the same as the pressure p_b beyond the nozzle exit if the ratio p_o/p is above the critical pressure ratio, but p_o will be greater than p_b if the ratio p_o/p is equal to the critical pressure ratio. It is thus seen that p_o/p has an important influence on the mass rate of discharge. Its critical value is given by $(p_o/p)_{cr}=\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$, the value of which is 0·528 for diatomic gases with $\gamma=1{\cdot}4$. The instantaneous rate of mass discharge, when p_b/p is equal to, or less than, 0·528, is thus obtained by substituting the value 0·528 for p_o/p in equation (2), giving

$$W=3{\cdot}89\,C_d\,A\sqrt{\frac{p}{v}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

By writing

$$\beta=\sqrt{2g\,\frac{\gamma}{\gamma-1}\left[\left(\frac{p_o}{p}\right)^{\frac{2}{\gamma}}-\left(\frac{p_c}{p}\right)^{\frac{\gamma+1}{\gamma}}\right]} \quad . \quad . \quad (4)$$

then, for all cases, *i.e.*, whether or not p_o/p is constant, equation (2) gives

$$W=C_d\,A\,\beta\sqrt{\frac{p}{v}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

When p_o/p is equal to the critical value, β is constant, otherwise β is a function of p_o/p.

The weight of gas discharged in an element of time dt is thus

$$dW=C_d\,A\,\beta\sqrt{\frac{p}{v}}\,dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

so that with equation (1)

$$C_d\,A\,\beta\sqrt{p\,\rho}\,dt=-V\,d\rho.$$

If the law of expansion of the gases within the vessel be denoted by $p/\rho^n=p_1/\rho_1^n$,

$$\text{then } p=p_1\left(\frac{\rho}{\rho_1}\right)^n$$

so that

$$C_d\,A\,\beta\sqrt{\frac{p_1}{\rho_1^n}\times\rho^{n+1}}\,dt=-V\,d\rho,$$

giving

$$C_d\,A\,\beta\,p_1^{\frac{1}{2}}v_1^{\frac{n}{2}}\,dt=-V\,\rho^{-\left(\frac{n+1}{2}\right)}\,d\rho \quad . \quad (7)$$

This is the fundamental equation which enables the time of discharge to be determined. If this time is long compared with the times of opening and closing of the nozzle valve the area A may be assumed constant. If, however, this is not the case the variation of A with time has to be taken into account in integrating equation (7). For a nozzle which is well rounded at inlet and parallel beyond the throat, C_d may also be assumed constant, otherwise its variation with the varying conditions of discharge must be taken into account. In the examples quoted below, which are taken from actual experiments, the time of opening and closing of a relatively large mushroom valve were very short compared with the total period of discharge, so that a constant area could safely be assumed and since the nozzles were short and of convergent-parallel design, C_d could be taken as constant and equal to 0·975.

It is convenient to refer to the times during which p_o/p remains constant at the critical value as the subcritical region and to the times during which p_o/p is above the critical value as the supercritical region.

Subcritical Region.—For the subcritical region β (equation (4)) is constant, so that, for the cases where A and C_d are also constant, equation (7) can be integrated directly. This gives

$$C_d\,A\,p_1^{\frac{1}{2}}v_1^{\frac{n}{2}}\,t=\left(\frac{2\,V\,\rho^{\frac{1-n}{2}}}{n-1}\right)_{\rho_1}^{\rho_2}=\frac{2\,V}{n-1}\left(v_2^{\frac{n-1}{2}}-v_1^{\frac{n-1}{2}}\right)$$

or

$$t=\frac{2\,V\,v_1^{\frac{n-1}{2}}\left\{\left(\frac{v_2}{v_1}\right)^{\frac{n-1}{2}}-1\right\}}{(n-1)\,C_d\,\beta\,A\,p_1^{\frac{1}{2}}v_1^{\frac{n}{2}}}$$

$$=\frac{2\,V}{(n-1)\,C_d\,\beta\,A\sqrt{R\,T_1}}\left\{\left(\frac{p_1}{p_2}\right)^{\frac{n-1}{2n}}-1\right\} \quad (8)$$

The following example serves to show the application of equation (8).

Air at a pressure of 114·8 lb. per square inch absolute, and temperature of 297 deg. Cent. absolute is discharged from a vessel having a capacity of 2·95 cubic feet through a convergent parallel nozzle having a cross-sectional area of $2{\cdot}86\times10^{-4}$ square feet, and a coefficient of discharge of 0·98. Find the time required to drop the pressure in the vessel from the initial value to 28 lb. per square inch absolute. The external pressure is 14·8 lb. per square inch absolute, and the mean index of expansion, as determined experimentally, is $n=1{\cdot}10$.

This expansion occurs entirely in the subcritical region, since the final pressure in the vessel is 28 lb. per square inch absolute, and the outer pressure is $p_b=14{\cdot}8$ lb. per square inch absolute, giving $p_b/p=14{\cdot}8/28=0{\cdot}528$. For all pressures above 28 lb. per square inch absolute, the ratio p_b/p is less than 0·528.

Equation (8) thus gives

$$t=\frac{2\times2{\cdot}95\left[\left(\frac{114{\cdot}8}{28{\cdot}0}\right)^{\frac{0{\cdot}10}{2{\cdot}20}}-1\right]}{2{\cdot}86\times10^{-4}\times0{\cdot}10\times0{\cdot}98\times3{\cdot}89\sqrt{96{\cdot}3\times297}}$$

$$=21{\cdot}2 \text{ secs.}$$

Supercritical Region.—In this region β is a function of p_o/p—see equation (4). The integration of equation (7) is thus more complicated than that for the subcritical region. Schüle‡ gives a graphical solution which is briefly explained below, and from this the author has deduced a method (also given below) of determining the times of discharge in the supercritical region by calculation alone.

Since

$$p=c\,\rho^n,$$

we have

$$d\rho=\frac{\rho\,d\,p}{p\,n}$$

so that equation (7) can be written as

$$C_d\,A\,\beta\,p_1^{\frac{1}{2}}v_1^{\frac{n}{2}}\,dt=-\frac{V\,v^{\frac{n-1}{2}}}{p^{\frac{n}{n}}}\,dp$$

Or since

$$p_1\,v_1^n=p\,v^n,$$

$$C_d\,A\,\beta\,p_1^{\frac{1}{2n}}v_1^{\frac{1}{2}}dt=-\frac{V}{n}\,p^{\frac{1}{2n}-\frac{3}{2}}\,dp \quad . \quad (9)$$

Also

$$dp=-\frac{p^2}{p_b}\,d\left(\frac{p_b}{p}\right)$$

so that equation (9) gives the time of discharge as

$$t=\frac{V}{n\,C_d\,A\,p_1^{\frac{1}{2n}}v_1^{\frac{1}{2}}}\int_{\frac{p_b}{p_1}}^{\frac{p_b}{p_2}}\frac{p^{\frac{1}{2n}+\frac{1}{2}}}{p_b\,\beta}\,d\left(\frac{p_b}{p}\right)$$

$$=\frac{V}{n\,C_d\,A\left(\frac{p_1}{p}\right)^{\frac{1}{2n}-\frac{1}{2}}\sqrt{R\,T_1}}\int_{\frac{p_b}{p}}^{\frac{p_b}{p_2}}\frac{d\left(\frac{p_b}{p}\right)}{\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}\beta} \quad (10)$$

Schüle determines graphically the value of this integral as follows:—The values of β for p_b/p, ranging from 0·53 to 1, are calculated from equation (4), *i.e.*,

$$\beta=\sqrt{\frac{2\times32\cdot2\times1{\cdot}4}{0{\cdot}4}\left[\left(\frac{p_b}{p}\right)^{\frac{2}{1{\cdot}4}}-\left(\frac{p_b}{p}\right)^{\frac{2{\cdot}4}{1{\cdot}4}}\right]}$$

The following table gives the calculated β values:

TABLE I.—*Values of* β.

p_b/p	0·53	0·60	0·65	0·70	0·75	0·80	0·85	0·90	0·95	0·98	1·0
β	3·880	3·836	3·750	3·621	3·432	3·175	2·846	2·390	1·751	1·124	0

The values of $\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}$ which occur in the denominator under the integral in equation (10) are also calculated for various p_b/p values, and are given in Table II:—

TABLE II.—*Values of* $\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}$.

p_b/p	0·53	0·60	0·65	0·70	0·75	0·80	0·85	0·90	0·95	0·98	1·0
$\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}$	0·5702	0·6363	0·6834	0·7293	0·7754	0·8210	0·8662	0·9111	0·9554	0·9830	1·0

The values of β as given in Table I are now multiplied by the corresponding values of $\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}$ as given in Table II. This gives the values of the denominator under the integral in equation (10), and the reciprocals give the values of the expression under the integral, *i.e.*, the values of

$$\frac{1}{\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}\beta}=k, \text{ say.}$$

These k values are given in Table III opposite.

The areas below the k curve when summed by means of a planimeter give the integral

$$z=\int\frac{d\left(\frac{p_b}{p}\right)}{\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}\beta} \quad . \quad . \quad . \quad (11)$$

The change in z accompanying a change in p_b/p can now be read from the graph, and from this the time taken to effect this change is found from equation (10).

Thus

$$t=\frac{V}{n\,C_d\,A\sqrt{R\,T_1}}\left(\frac{p_1}{p_b}\right)^{\frac{1}{2}-\frac{1}{2n}}(z_2-z_1) \quad . \quad (12)$$

where

$$z_2-z_1=\int_{p_1}^{p}\frac{d\frac{p_b}{p}}{\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}\beta}$$

The curve of z values is plotted in Fig. 1 to a base of p_b/p values.

* Heat Engines Department, James Watt Engineering Laboratories, University of Glasgow.

† "Energy Content of High-pressure Gases," THE ENGINEER, September 2nd, 1938.

‡ See Schüle's "Technische Thermodynamik," Bd. II, pages 366–395.

This process can be repeated for other values of n giving a series of z curves, but these lie within such a narrow field that no serious error is involved in accepting the mean value $n=1\cdot3$ throughout.

APPROXIMATE TIME OF DISCHARGE IN THE SUPERCRITICAL REGION

The following modification of Schüle's graphical method is suggested by the author, since it enables the results to be obtained by calculation alone. On referring to Fig. 1 it will be noticed that the z curve is very nearly straight for values of p_b/p ranging from 0·528 to 0·95. The equation of the mean straight line over this region is

$$z=0\cdot406\ p_b/p-0\cdot215,$$

so that the approximate equation for the time of discharge when the pressure drops from p_1 to p_2 in the supercritical region becomes

$$t_2=\frac{V}{n\,C_d\,A\sqrt{R\,T_1}}\left(\frac{p_1}{p_b}\right)^{\frac{1}{2}-\frac{1}{2n}}(z_2-z_1)$$

$$=\frac{V}{n\,C_d\,A\sqrt{R\,T_1}}\left(\frac{p_1}{p_b}\right)^{\frac{1}{2}-\frac{1}{2n}}\left\{\left(\frac{0\cdot406\,p_b}{p_2}-0\cdot215\right)-\left(\frac{0\cdot406\,p_b}{p_1}-0\cdot215\right)\right\}$$

$$=\frac{0\cdot406\,V\,p_b}{n\,C_d\,A\,p_2\sqrt{R\,T_1}}\left(\frac{p_b}{p_1}\right)^{\frac{n+1}{2n}}(p_1-p_2) \quad . \quad . \quad (13)$$

This equation is applicable if the ratio p_b/p does not exceed 0·95. The case in which p_b/p exceeds 0·95 is considered below.

If the expansion starts at or above the critical pressure, then $p_b/p_1=0\cdot528$, so that equation (13) becomes

$$t_2=\frac{0\cdot406\,V\,(p_1-p_2)}{n\,C_d\,A\,p_2\sqrt{R\,T_1}\times1\cdot893^{\frac{n+1}{2n}}} \quad . \quad . \quad . \quad (14)$$

The graph of $1\cdot893^{\frac{n+1}{2n}}\times n$, which occurs in the denominator of this expression, has been plotted to a base of n values in Fig. 2. It is practically a straight line, the equation of which is

$$y=1\cdot315\,n+0\cdot578,$$

and hence equation (14) can be written in the simpler form

$$t_2=\frac{0\cdot406\,V\,(p_1-p_2)}{(1\cdot315\,n+0\cdot578)\,C_d\,A\,p_2\sqrt{R\,T_1}} \quad . \quad . \quad (15)$$

APPROXIMATE TREATMENT FOR VALUES OF p_b/p LYING BETWEEN 0·95 AND 1·0

For values of p_b/p lying between 0·95 and 1·0 the equation of the mean straight line through the z curve in Fig. 1 is given by

$$z=0\cdot92\ p_b/p-0\cdot702,$$

so that in this region the time of discharge when the pressure drops from p_1 to p_2 is given approximately by

$$t_2=\frac{V}{n\,C_d\,A\sqrt{R\,T_1}}\left(\frac{p_1}{p_b}\right)^{\frac{1}{2}-\frac{1}{2n}}(z_2-z_1)$$

$$=\frac{V}{n\,C_d\,A\sqrt{R\,T_1}}\left(\frac{p_1}{p_b}\right)^{\frac{1}{2}-\frac{1}{2n}}\left\{\left(0\cdot92\frac{p_b}{p_2}-0\cdot702\right)-\left(0\cdot92\frac{p_b}{p_1}-0\cdot702\right)\right\}$$

$$=\frac{0\cdot92\,V}{n\,C_d\,A\sqrt{R\,T_1}}\left(\frac{p_b}{p_1}\right)^{\frac{n+1}{2n}}(p_1-p_2) \quad . \quad . \quad (16)$$

If the expansion commences with $p_b/p=0\cdot95$, equation (16) becomes

$$t_2=\frac{0\cdot92\,V\,(p_1-p_2)}{1\cdot053^{\frac{n+1}{2n}}\,n\,C_d\,A\,p_2\sqrt{R\,T_1}} \quad . \quad . \quad . \quad (17)$$

The function $1\cdot053^{\frac{n+1}{2n}}\times n=y$, which occurs in the denominator of equation (17), has been plotted to a base of n values in Fig. 3. The equation of the resulting curve, which is very nearly a straight line, is

$$y=1\cdot02\,n+0\cdot033.$$

Inserting this in equation (17) gives

$$t_2=\frac{0\cdot92\,V\,(p_1-p_2)}{C_d\,A\,p_2\sqrt{R\,T_1}\,(1\cdot02\,n+0\cdot033)} \quad . \quad . \quad (18)$$

TABLE III.—*Values of* $k=\dfrac{1}{\left(\frac{p_b}{p}\right)^{\frac{1}{2n}+\frac{1}{2}}\beta}$

p_b/p	0·53	0·60	0·65	0·70	0·75	0·80	0·85	0·90	0·95	0·98	1·0
k	0·4521	0·4096	0·3901	0·3787	0·3758	0·3836	0·4057	0·4591	0·5977	0·9050	$-\infty$

TABLE IV.—*Values of* z *with* $n=1\cdot3$

p_b/p	0·528	0·55	0·575	0·60	0·625	0·65	0·675	0·70	0·725	0·75
z	0	0·00985	0·0205	0·0310	0·0413	0·0510	0·0608	0·0702	0·0795	0·0890
p_b/p	0·775	0·80	0·825	0·85	0·875	0·90	0·925	0·95	0·975	1·000
z	0·0984	0·1076	0·1172	0·1276	0·1380	0·1490	0·1608	0·1747	0·1918	0·2300

The following example serves to show the application of these equations :—

Air, at a pressure of 114·8 lb. per square inch absolute, and a temperature of 297 deg. Cent. absolute, is discharged from a vessel having a capacity of 2·95 cubic feet through a convergent-parallel nozzle having a cross-sectional area of $2\cdot86\times10^{-4}$ square feet. It is required to calculate the time taken for the air pressure in the vessel to drop to that of the external pressure of 14·8 lb. per square inch absolute. The coefficient of discharge for the nozzle may be taken equal to 0·98.

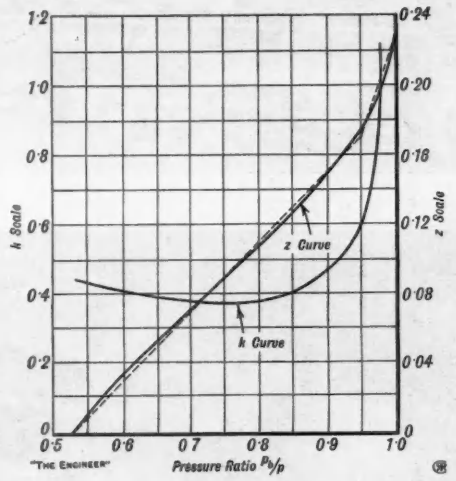


FIG. 1

The time actually taken was measured experimentally and found to be 36 seconds.

The critical pressure, referred to the external pressure, is $p_{cr}=14\cdot8/0\cdot528=28\cdot0$ lb. per square inch absolute. The mean index of expansion for this pressure drop and for the given nozzle was found experimentally to be $n=1\cdot10$. The time of discharge for this subcritical period is given by equation (8), *i.e.*,

$$t_1=\frac{2\,V}{(n-1)\,C_d\,A\,\beta\sqrt{R\,T_1}}\left\{\left(\frac{p_1}{p_2}\right)^{\frac{n-1}{2n}}-1\right\}$$

Here $p_2=p_{cr}=28\cdot0$ lb. per square inch absolute; $V=2\cdot95$; $A=2\cdot86\times10^{-4}$ ft.²; $\beta=3\cdot90$; $T_1=297$ deg. Cent. absolute; $R=96\cdot3$; $n=1\cdot10$; $C_d=0\cdot98$.

These give

$$t=\frac{2\times2\cdot95}{0\cdot10\times0\cdot98\times3\cdot90\times2\cdot86\times10^{-4}\sqrt{96\cdot3\times297}}\left[4\cdot09^{\frac{0\cdot10}{2\cdot20}}-1\right]=21\cdot1\text{ sec.}$$

The time of discharge in the supercritical period, *i.e.*, while the pressure decreases from 28·0 lb. per square inch absolute to the external pressure of 14·8 lb. per square inch absolute, is given by equation (12), which, with $z_1=0$ and $p_1=p_{cr}$, becomes

$$t_2=\frac{V\,z}{n\,C_d\,A\sqrt{R\,T_{cr}}}\left(\frac{p_{cr}}{p_b}\right)^{\frac{1}{2}-\frac{1}{2n}}$$

The value of T_{cr} is found from

$$T_{cr}=T_1\left(\frac{p_{cr}}{p}\right)^{\frac{n-1}{n}}=\frac{297}{4\cdot09^{0\cdot10/1\cdot10}}=262\text{ deg. Cent. absolute.}$$

The value of z is found from Fig. 1 for the ratio $p_b/p=\frac{14\cdot8}{14\cdot8}=1$, and equals 0·23. The index of expansion n is reduced in this region and is taken as 1·09.

Hence,

$$t_2=\frac{2\cdot95\times0\cdot23}{1\cdot09\times0\cdot98\times2\cdot86\times10^{-4}\sqrt{96\cdot3\times262}}\times\left(\frac{28\cdot0}{14\cdot8}\right)^{\frac{1}{2}-\frac{1}{2\cdot18}}=14\cdot4\text{ sec.}$$

The total time of discharge is thus $t=t_1+t_2=21\cdot1+14\cdot4=35\cdot5$ sec.

The percentage error in the calculated time is thus

$$\left(\frac{36-35\cdot5}{36}\right)100=\frac{0\cdot5\times100}{36}=1\cdot4\text{ per cent.}$$

In making use of the approximate method it is necessary to consider the expansion in the supercritical region as occurring in two stages. The first stage occurs with a drop in pressure from the critical value of 28 lb. per square inch absolute to the pressure $p=p_b/0\cdot95=14\cdot8/0\cdot95=15\cdot6$ lb. per square inch absolute. The time for this period is given by equation (15), *i.e.*,

$$t_2=\frac{0\cdot406\,V\,(p_1-p_2)}{(1\cdot315\,n+0\cdot578)\,C_d\,A\,p_2\sqrt{R\,T_1}}$$

Here $p_1=p_{cr}=28\cdot0$ lb. per square inch absolute; $p_2=p=15\cdot6$ lb. per square inch absolute; $n=1\cdot09$;

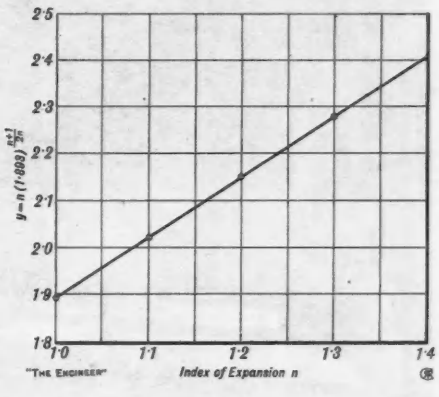


FIG. 2

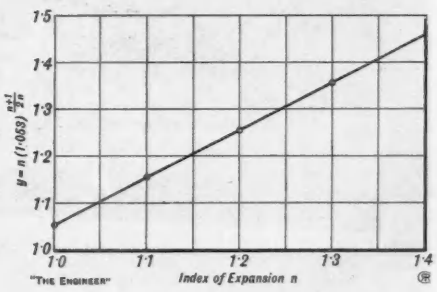


FIG. 3

$T_1=T_{cr}=262$ deg. Cent. absolute. The other values are as given above.

Hence

$$t_2=\frac{0\cdot406\times2\cdot95\,(28\cdot0-15\cdot6)}{(1\cdot315\times1\cdot09+0\cdot578)\,0\cdot98\times2\cdot86}\times10^{-4}\times15\cdot6\sqrt{96\cdot3\times262}=10\cdot7\text{ sec.}$$

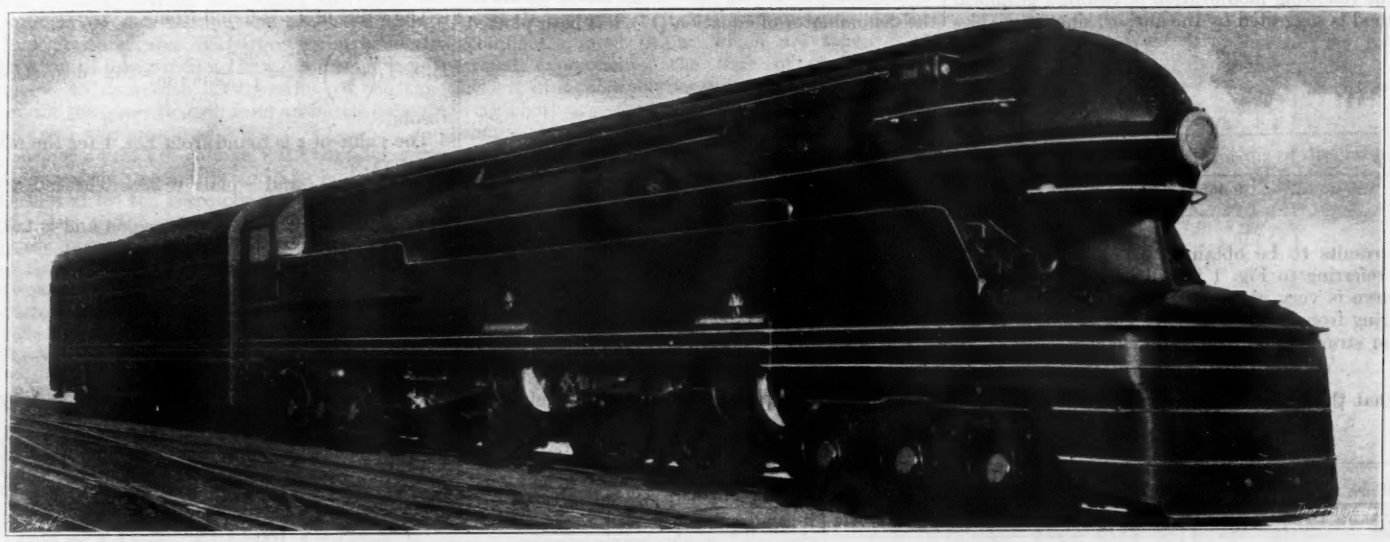
For the second stage in the supercritical region equation (18) gives

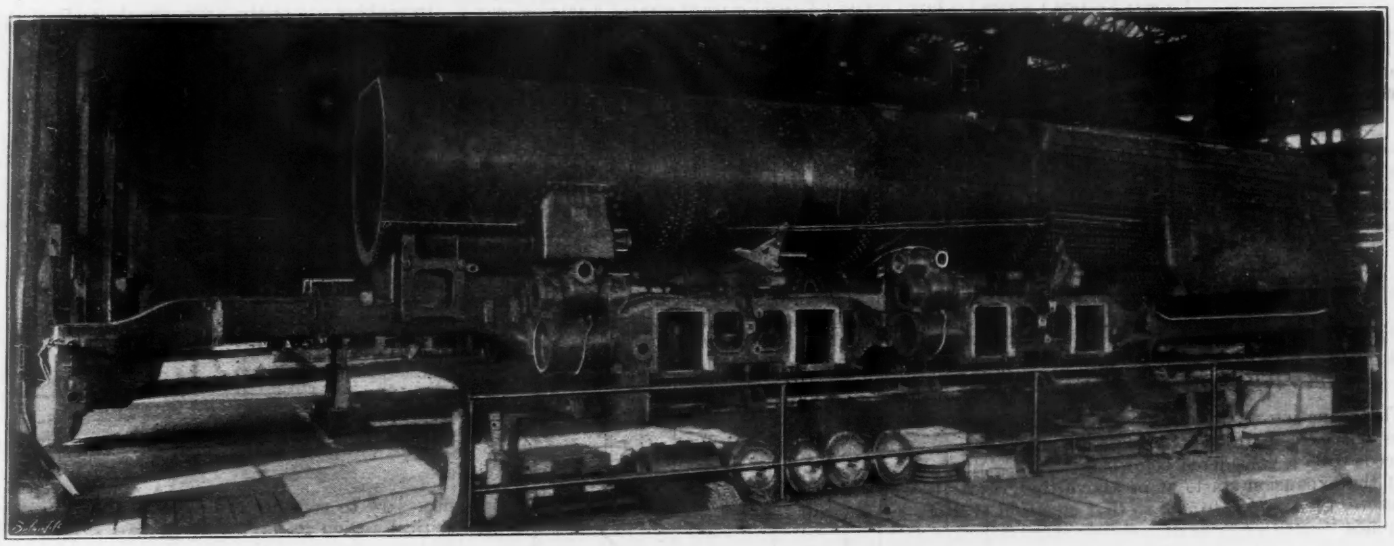
$$t_2=\frac{0\cdot92\,V\,(p_1-p_2)}{C_d\,A\,p_2\sqrt{R\,T_1}\,(1\cdot02\,n+0\cdot033)}$$

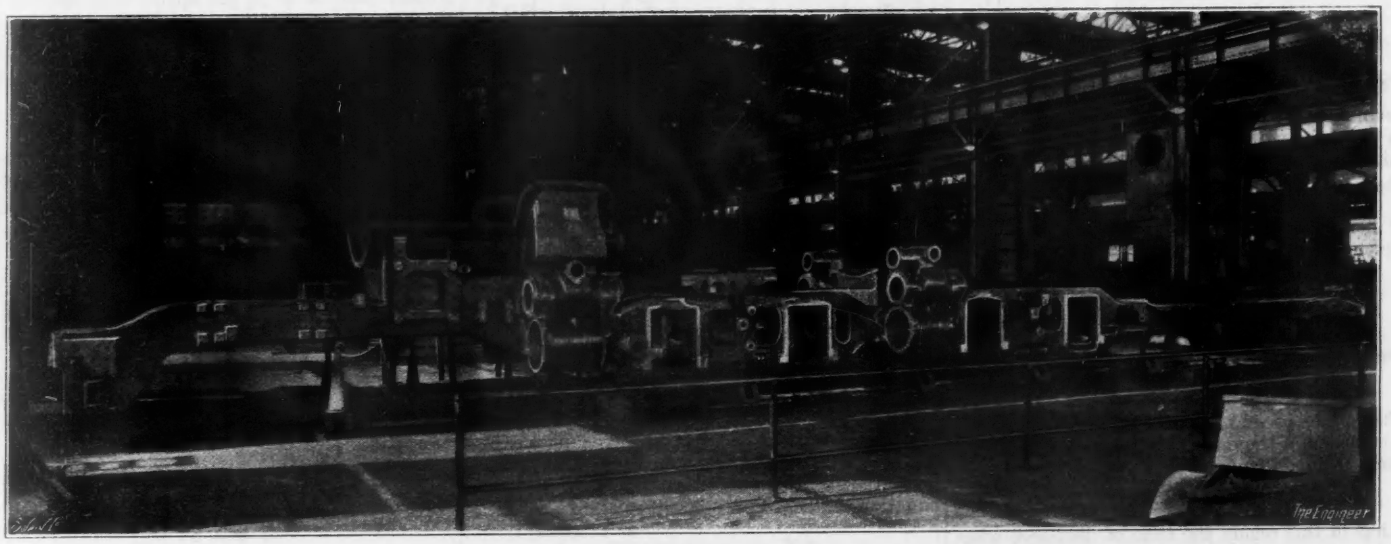
Here $p_1=15\cdot6$ lb. per square inch absolute; $p_2=14\cdot8$ lb. per square inch absolute; $n=1\cdot09$.

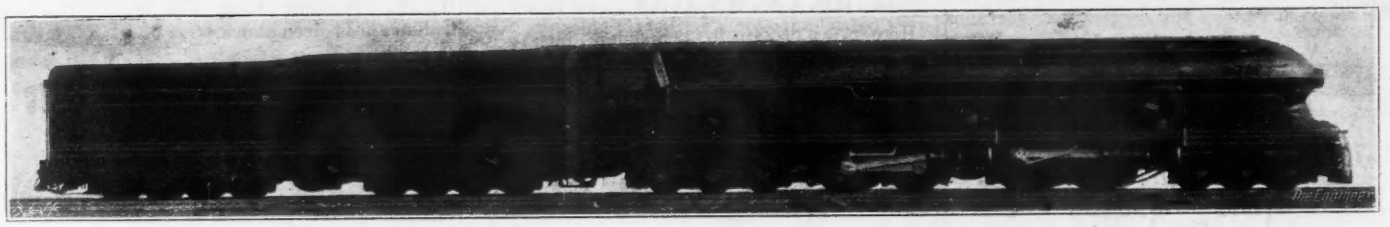
PENNSYLVANIA RAILROAD 6500 H.P. EXPRESS LOCOMOTIVE

(*For description see opposite page*)









T_1 is the temperature at the beginning of this stage and is found from

$$T_1 = \frac{T_{cr}}{\left(\frac{p_{cr}}{p_1}\right)^{\frac{n-1}{n}}} = \frac{262}{\left(\frac{28}{15{\cdot}6}\right)^{\frac{0{\cdot}09}{1{\cdot}09}}} = 250 \text{ deg. Cent.}$$

absolute. These give

$$t_3 = \frac{0{\cdot}92 \times 2{\cdot}95\,(15{\cdot}6 - 14{\cdot}8)}{0{\cdot}98 \times 2{\cdot}86 \times 10^{-4} \times 14{\cdot}8\,\sqrt{96{\cdot}3 \times 250}\,(1{\cdot}02 \times 1{\cdot}09 + 0{\cdot}033)}$$

$= 2{\cdot}9$ sec.

The time of discharge in the supercritical region, as given by the approximate method, is thus $t_2 + t_3 = 10{\cdot}7 + 2{\cdot}9 = 13{\cdot}6$ sec., as against 14·4 sec. found by the graphical method. The percentage difference is $\frac{(14{\cdot}4 - 13{\cdot}6)}{14{\cdot}2} \times 100 = \frac{0{\cdot}8 \times 100}{14{\cdot}2} = 5{\cdot}6$ per cent.

On the total period the percentage difference is $\frac{(35{\cdot}5 - 34{\cdot}7)}{35{\cdot}5} \times 100 = 2{\cdot}3$ per cent.

Pennsylvania Railroad 6500 H.P. Locomotive

WITH this issue we present as a Supplement drawings of some of the more interesting parts of one of the most remarkable locomotives of the day. It is almost certainly the most powerful unarticulated engine in existence, and is probably unique in that the carrying wheels are arranged in two six-wheeled trucks, whilst the driving wheels are on four axles, each pair being driven by two cylinders. The wheel arrangement is therefore, as will be seen from the "portraits" on the opposite page, 6–4–4–6. The tender has two eight-wheel trucks. The overall length from buffers to buffers is no less than 140ft. 2½in., and the total weight over 470 English tons. A very remarkable feature is the frame—to be seen in two views on the opposite page—which is a single steel casting nearly 78ft. long and weighing over 43 tons. It will be observed that the cylinders and the saddle are comprised in the casting.

This vast machine is "faired" rather than streamlined, and is expected to attain a speed of 100 m.p.h. on level tangent track whilst hauling passenger trains weighing 1200 tons. It was built at the Altoona works of the Pennsylvania Railroad, but the design was made by engineers of the American, Baldwin, and Lima Locomotive Companies in collaboration with the engineers of the Pennsylvania Railroad. It is now being displayed at the New York Exhibition, where it is mounted on rollers by which the wheels are rotated.

It will be seen from our illustration and drawings that the fire-box is of colossal proportions. From the back plate to the back tube plate is over 27ft., and the grate area—for bituminous coal—is 132 square feet. The box may be described as a modified Belpaire, and our drawing of it calls for a word of explanation. It will be noted that the now familiar siphons are not fitted, but seven arch tubes, 5½in. diameter, tied to the centre of the crown plate by 7in. tubes, pass from side to side, as shown in the accompanying half-tone engraving. The designed working pressure is 300 lb. and the total evaporative surface is 5661 square feet. A single-pass superheater of 2085 square feet is fitted. The automatic stoker is of the Standard design. There is no dome in the ordinary sense of the word, and so far as our information goes no special provision for delivering dry steam is made, the ordinary slotted dry pipe being fitted.

The cylinders are all of the same size—22in. by 26in., and the driving wheels are 84in. in diameter; steam is distributed by Walschaerts gear operating 12in. piston valves with a maximum stroke of 7½in.—quite ordinary engines. The wheels are of the Baldwin disc type, and the journals, 12½in. by 13in., are fitted with Timken roller bearings in split housings. The coupling-rods have spherical floating bushes of bronze.

In our Supplement to-day we give drawings of the two carrying trucks. That under the smoke-box is of what is known as the increasing resistance geared lateral motion type, and has a three-point suspension. The leading wheels are cross equalised, whilst the others are equalised together. The cross equaliser of the front wheels is pivoted to the frame of the truck. The springing arrangement is indicated pretty well in our drawing. Both trucks are fitted with Timken roller bearings. The fire-box end of the locomotive is supported on the hind end of the trailer truck through a roller centring device.

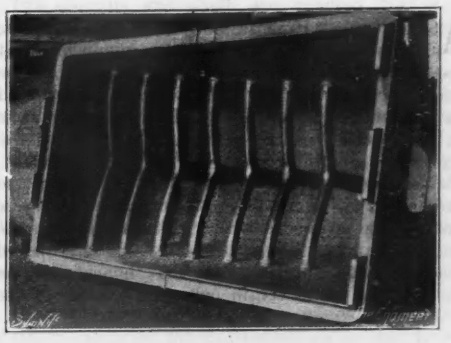
In common with a good many modern engines, there are two chimneys with two blast pipes, as shown in one of our drawings. The blast nozzles appear to be perfectly simple and are free from any of the adjuncts now familiar in European practice. Their area is very nearly 32 sq. in. each.

It will have been gathered that the tender is of exceptional proportions; as a matter of fact, it carries some 22 tons of coal and 24,230 gallons of water. It was built up by welding on a cast steel water bottom underframe nearly 59ft. long. Its wheels are 36in. in diameter, and as elsewhere in the engine the journals have Timken roller bearings.

Other interesting data may be gleaned from the weight diagram and the drawings.

From this brief description it will be seen that the designers of this vast machine have stuck closely to the simplest established practice. No doubt there are many accessories and details about the engine, but in its broad aspects it is, apart from its wheel arrangement, classical and orthodox. We note that a feed-water and a cab-signalling system are fitted. Presumably there is no intention to attempt a marked reduction in fuel consumption and the streamlining is not carried below the running board. As a matter of fact the immense length of the engine and tender give the assembly an arrow-like appearance. We can see no effort to deal with the smoke nuisance, and it is possible that by reason of the distance of the cab from the smoke-box the exhaust may not actually reach the windows, but we imagine that it would, nevertheless, interfere materially with the look-out. If engines get much longer, a telescope extending from the front to the cab side will be a sheer necessity!

The most notable feature, apart from mere size, is the use of two separate engines in a rigid frame locomotive. As is well known, two-cylinder engines are by far the most favoured type in North American practice. Moving parts between the frames are not looked upon with favour, and, further, the distance between bar frames leaves little space compared with that available when plate frames are employed. This being the case, the plan adopted by the Pennsylvania Railroad offers an interesting solution of the problem when four cylinders are required. From the point of view of tractive effort only, two cylinders, approximately 31in. diameter, would have been required; the provision, however, of four of smaller diameter, spaced at proportionately



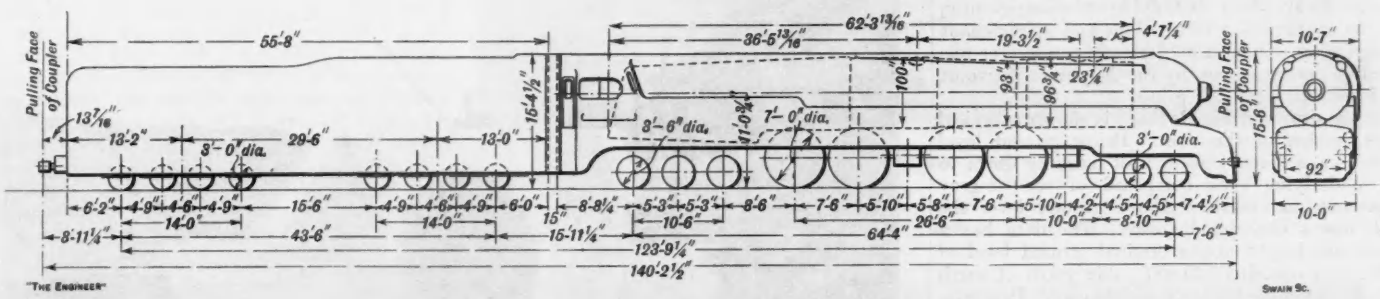
INSIDE FIRE-BOX

closer centres, and with lighter reciprocating parts, will be accepted as more suited for high-speed passenger service, while the arrangement adopted, though adding somewhat to the length of the engine, maintains the feature of accessibility associated with outside two-cylinder engines.

Dimensions of Pennsylvania Passenger Engines.

Class	"K.4.s."	"M.1.a."	"S.1."
Type	4–6–2	4–8–2	6–4–4–6
Cylinders, number, diameter, stroke, inches	Two, 27×28	Two, 27×30	Four, 22×26
Driving wheels, diameter	6ft. 8in.	6ft.	7ft.
Boiler working pressure, lb. per square inch	305	250	300
Heating surfaces, square feet—			
Fire-box	323	395	660
Tubes and flues	3,735	4,303	5,001
Total evaporation	4,040	4,698	5,661
Superheater	943	1,634	2,085
Combined	4,983	6,332	7,746
Grate area, square feet	69·9	69·9	132
Weights, lb.—			
On drivers	201,830	271,000	281,440
Total engine	308,890	390,000	608,170
Tender, loaded	171,400	378,360	451,840
Total, locomotive	480,290	768,360	1,060,010
Fuel, lb.	27,100	63,000	52,900
Water, gallons (U.S.)	7,850	22,000	24,230
Rated tractive force, lb.	44,460	64,550	76,400
Total locomotive weight, tons (2240 lb.)	214½	342	473¼

NOTE.—A number of class "K.4.s." engines have been fitted with large tenders similar to those used for the class "M.1.a" of the latest lot built. Dimensions of class "M.1.a" as for latest series with large tenders.



P.R.R. 6-4-4-6 LOCOMOTIVE—WEIGHT DIAGRAM

The locomotive constitutes a considerable advance in power compared with previous designs, and in order to bring it into proper perspective with the engines now in passenger traffic on the Pennsylvania, a short tabulation is appended setting out the principal dimensions, along with those of the "Pacific" and "Mountain" type locomotives, classes "K.4.s" and "M.1.a," previously designed in Altoona, and of which large numbers are in successful service.

AWARD TO DR. TIMOSHENKO.—The Lamme Medal for 1938 has been awarded to Dr. Steven P. Timoshenko by the American Society for the Promotion of Engineering Education. The Lamme Medal, founded to honour the memory of Mr. B. G. Lamme, who, at his death in 1924, was chief engineer of the Westinghouse Electric and Manufacturing Company, is presented annually to an engineer as recognition for outstanding accomplishment. The citation on the medal awarded to Dr. Timoshenko reads: "For devotion to teaching as an art; for his distinguished class-room work as a teacher; for his ability to inspire his students toward ideals of scholarship and service; for his leadership in developing graduate work in mechanics, elasticity, and strength of materials; for the enthusiasm he has imparted to many disciples to go from his class room to devote themselves to research and to teaching; and for his continuing influence on them in their development."

Talybont Reservoir and Filtration Plant

AS long ago as 1920 the Corporation of Newport, Monmouthshire, came to the conclusion that increased storage of water would soon become necessary, and in that year a Bill was presented in Parliament for the construction of a reservoir in Glyn Collwn, Talybont-on-Usk, Breconshire, and the laying of a trunk main thence to Newport. Matters were not at that time at all urgent, so that when the Bill was approved the works were not at once proceeded with. But the whole of the enclosed land of the drainage area of the proposed reservoir was purchased so that henceforth the Corporation could retain complete control of the gathering ground and thereby prevent so far as possible any pollution of the water. In addition a trunk main of about 5 million gallons per day capacity was constructed, and in 1927 Newport first received water from Talybont.

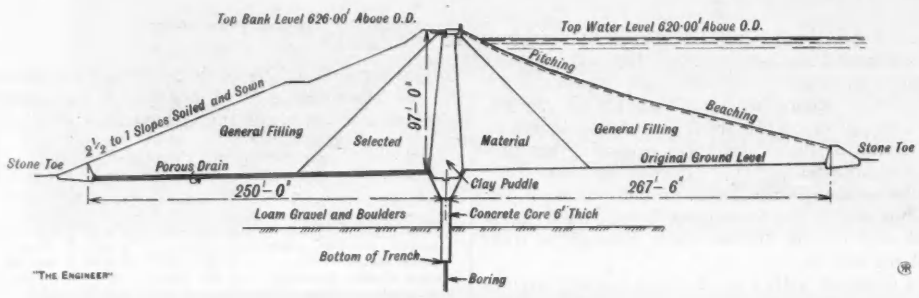


FIG. 1—CROSS SECTION OF DAM

The actual decision to put the necessary works in hand for the building of the proposed dam was taken in 1930, when the Government offered financial assistance to the Corporation provided the work was begun immediately. The exploration and examination of the various sites in the valley which might be occupied by the dam took some considerable time. Trial pits were put down in various places to discover the nature of the underlying strata. Meanwhile, the top water level of the reservoir being known, the diversion of a road on the west side of the valley to a line further up the hillside was undertaken and completed in 1932. In that same year a contract was let to Mr. John McColville, of Abergavenny, for the construction of the dam and appurtenant works at a cost of £367,700. The reservoir was officially declared open by the Mayor of Newport on June 29th last.

In the drawing, Fig. 1, there is shown a typical cross section of the dam. Below ground level there is a concrete cut-off wall reaching down to the underlying rock composed of reddish-grey sandstone and marls. Above ground level the dam has a clay puddle core. The dam has a maximum height above original ground level of 97ft., and contains 520,000 cubic yards of earth and 40,000 cubic yards of puddle clay. It creates a reservoir with an area of 320 acres and a capacity of 2567 million gallons. The drainage area amounts to 9·37 square miles of moorland and high mountain pasture, rising to a maximum height 2500ft. above sea level, and having an average rainfall of 68½in. per annum. The run-off in the three driest consecutive years is estimated at 15 million gallons per day. Of that amount, 5 million gallons per day are required to be passed down the river as compensation water.

One of the first works undertaken by the contractor was that of providing accommodation for the men employed on the works. Twelve timber huts were erected, each capable of accommodating twenty-four men, a hutkeeper, his wife, and a domestic, and each divided into a dormitory, dining room, kitchen, and staff quarters. For the sanitary arrangements a water carriage system was adopted and a small sewage disposal works was built to deal with it.

The chief work of the contractor was that of constructing the dam. It is built upon strata consisting of two groups. The surface deposits consist of loam, gravel, and boulders of glacial origin. It was necessary, of course, to carry the concrete core wall down past this porous material to the bedrock of old red sandstone, consisting of alternate beds of sandstones and marls of various thicknesses dipping towards the reservoir in a generally south-south-east direction. The concrete core trench, 6ft. in width, had to be sunk to a maximum depth of 85ft. Before it was filled with concrete 145 borings were driven into the underlying rock and grout was injected under pressure. As much as 434 tons of liquid cement grout was taken. Borings were driven to a maximum depth of 135ft. below the bottom of the trench. Photographs taken in 1934 and 1935 respectively and reproduced on page 72 show the progress of the work. In the first the completed concrete core is to be seen at the far end of the trench, whilst in the second work has been carried further forward; the clay puddle core is to be seen in the foreground, and the concrete core wall further back. During the construction of the dam the river was diverted through the 12ft. concrete culvert illustrated in Fig. 2. This structure founded on rock on the west side of the valley was later used to carry 30in. service water and 25in. scour pipes after the completion of the dam. A valve shaft (page 72) is connected to the culvert at a point 87ft. upstream from the centre line of the dam. It is 12ft. internal diameter and contains valves and draw-off pipes at depths 20ft., 40ft., and 90ft. below top water level. The chamber on top of the shaft is octagonal in plan and contains the headstocks for the valves and a water level recorder.

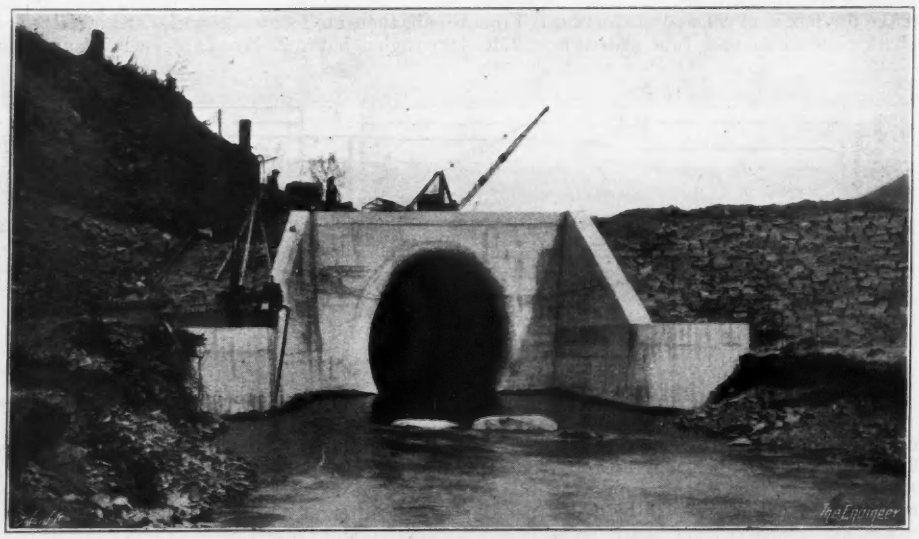


FIG. 2—CULVERT DAM

Provision has been made in the arrangement of the dam for the discharge of flood water at the rate of 1800 million gallons per day. The overflow weir (Fig. 3) is situated at the western end of the dam, and extends upstream with a slight curvature in plan. It has a total length of 275ft. at a level 620ft. above O.D. Overflowing water is led away under a road bridge in a masonry channel 40ft. in width. It falls over a number of steps in the channel and finally is discharged over a spillway apron (page 72) into a stilling pool 10ft. deep before rejoining the old river channel.

FILTRATION PLANT

The filtration plant is situated on a site immediately below the embankment of the reservoir, the floor level being at 524 O.D., so that the static head on the plant when the reservoir is full is 90ft. The purpose of the plant is the removal of suspended matter and colour from the water, for neutralising the acidity so as to prevent corrosive action on pipes and fittings, and for safeguarding the bacteriological purity by sterilisation. The complete installation has been designed for a total ultimate capacity of 10 million gallons per day. The first instalment of twelve filters having a capacity of 5 million gallons per day was completed in September, 1937, and a further instalment of four filters, bringing the present capacity of the plant to 8 million gallons per day, was brought into service last April. The building comprises a central administration block in which are situated the office, laboratory, workshop, chlorination room, meters, and chemical plant. The two wings, extending from the administration building, each accommodate twelve filters. The raw water main enters the building at the front where it is connected into the system of manifold pipes carried in trenches below floor level and having chequer plate covers. A Kent venturi meter of the electrical transmitter type provides an indication of the flow. Instruments are mounted in a panel standing in the centre of the administration room (Fig. 6), which serves also to support the three clarity bowls in which samples of the raw water, chemically treated water and filtered water are continuously visible.

The colour and suspended matter in the raw water are present in a form such that coagulation is necessary to enable them to be removed by the filters, and for this purpose a suitable dose of sulphate of alumina is added. This chemical reacts with the bicarbonates in the water to form a gelatinous flocculent precipitate of alumina hydroxide which neutralises the potential of the finely divided particles present in the water, and enables them to build up or coagulate into larger particles. The alumina hydroxide floc also absorbs organic colour from the water and entangles a large percentage of the bacteria present. Although the Talybont water is very soft, there is usually sufficient bicarbonates in the water to provide a satisfactory reaction with the alumina. Under certain conditions, however, it becomes necessary to make up for the deficiency of bicarbonates by adding a suitable dose of chalk to the raw water. After coagulation and filtration the water is in a condition in which it would have a corrosive action on metals; it is corrected by a small dose of lime applied to the filtered water main at the point where it leaves the filter house.

The chemical dosing apparatus (Fig. 4) is of the automatic proportioning pump type, incorporating an improved system of control recently developed and patented by the Candy Filter Company, Ltd. The alumina solution is made up in asphalt-lined concrete tanks (Fig. 5), each equipped with hand-operated stirrer gear, dissolving trays, level gauges, and other accessories. The tanks are situated near the alumina store. For the lime and chalk there are four steel de-mix type tanks (Fig. 7), each equipped with continuously running horizontal paddle shafts. The lime and chalk store is partitioned off by means of a wall through which the charging hoppers of

the four tanks project. With this arrangement the lime and chalk dust, which inevitably rise in the air when bags are being opened, is confined to the store. The chemicals are injected into the water by means of variable stroke ram pumps, in duplicate for each chemical, so that there are, in all, six pumps. They are operated by silent chain drives from a main countershaft, each pump having a lever-operated clutch. Suction and delivery piping is cross connected, so that for each chemical either pump can draw from either tank.

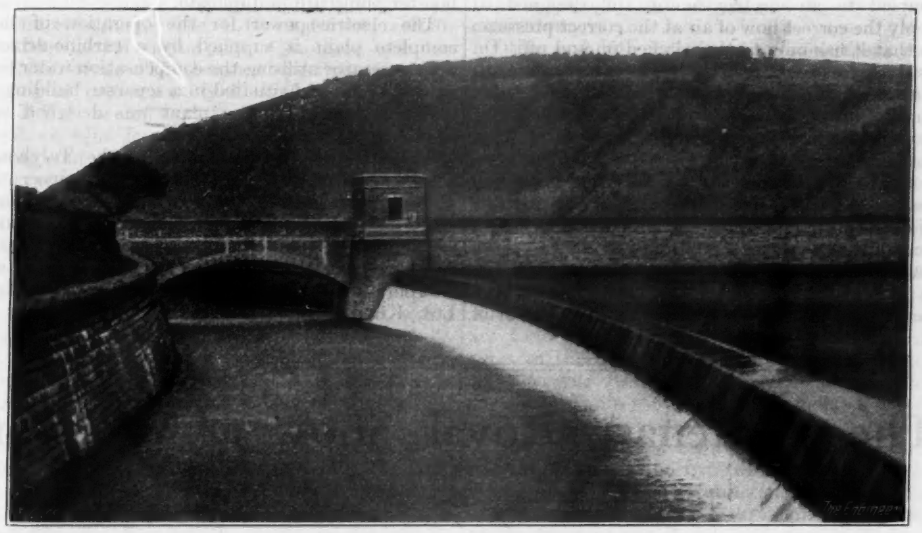


FIG. 3—OVERFLOW WEIR

Automatic proportioning of the rate of feed of the chemicals is secured by a device which causes the pumps to be driven at a speed strictly proportional to the flow of water in the main. The essential feature of this automatic controller is the centrifugal balancer which makes use of the fundamental principle that the pressure generated at the periphery of a rotating hydraulic impeller is proportional to the square of the speed. In a venturi tube, inserted in the main, the differential pressure created between the upstream and throat is also proportional to the square of the flow. It follows therefore that if the pressure generated at the periphery of the impeller is equal to the differential head of the venturi tube, the speed at which the impeller is being rotated will be exactly proportional to the flow. Pressure connections are made between the venturi tube and the centrifugal balancer, which is rotated by a drive from the same main shaft, which drives the chemical pumps. The prime mover is an electric motor coupled to a variable-speed gear, by which an infinite variation in the driving speed is obtained by the movement of a small lever.

By an ingenious, but simple, system, the pressure connections between the venturi tube and centrifugal balancer are connected to a sensitive ring balance relay which controls the movement of the lever on the variable-speed gear. The complete system functions so that if the flow passing through the venturi tube increases, the corresponding increase in the differential head causes the relay to increase the speed of the main pump shaft until the pressure generated by the centrifugal balancer at the higher speed again balances the differential pressure created by the venturi tube. It has been found that, in practice, the controller responds to variations in the flow with the greatest accuracy, and is totally unaffected by variations in load or other external factors.

The alumina and chalk are injected into the raw water main at the entrance to the filter house at the inlet end of a mixing box having internal baffles. These baffles set up the turbulence necessary to ensure that the chemicals are thoroughly mixed with the water before it reaches the filters.

There are at present installed sixteen Candy horizontal pressure type filters, each 8ft. diameter by 27ft. 6in. long, on the cylinder with an effective filtering area of 200 square feet each. The units are arranged in two rows with a central gangway, and all the control valves are grouped for operation from floor level.

Each filter is equipped with a gauge panel in which is mounted the differential gauge giving a simultaneous reading of the unfiltered and filtered water pressure and the filtering head loss, and a mercurial flow indicator with double scale arranged to give readings of both normal filtering flow and upwash rate. At the base of the panel are fitted push-buttons for remote control of the air scour compressor, together with isolating and change-over valves for the pressure gauge and flow indicators. Concealed lighting is provided for both the dial and flow indicator scales.

The process of washing a filter, which takes place once in every twenty-four to forty-eight hours, consists of isolating the unit from the mains and applying compressed air for the agitation

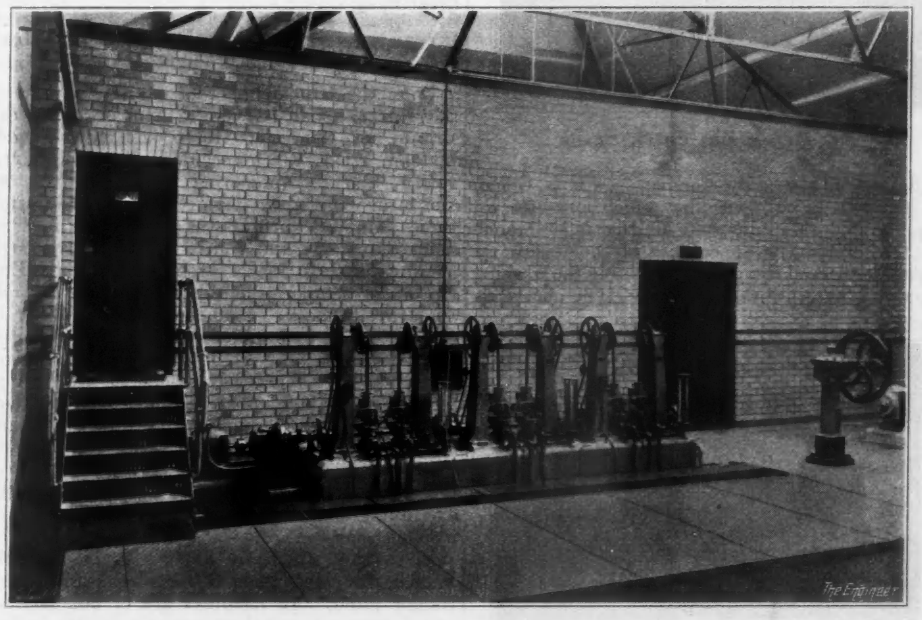


FIG. 4—CHEMICAL PUMPS

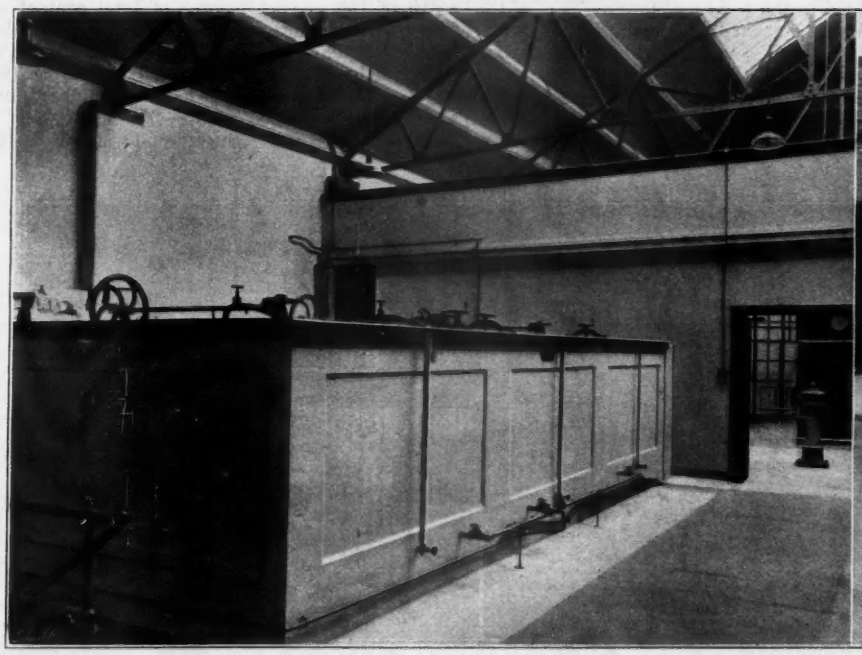


FIG. 5—ALUMINA TANKS

FIG. 6—CONTROL PANEL AND CLARITY INDICATOR

of the sand bed accompanied by and followed by a reverse flow of filtered water which carries away the dislodged impurities to waste. The actual operation of washing out occupies approximately fifteen minutes, after which the unit is automatically brought into service again, starting at a slow rate and increasing gradually up to the

FIG. 7—LIME AND CHALK TANKS

full rate. This "slow-starting," as it is called, is effected by a controller which operates an equilibrium valve inserted in the inlet branch to the filter. The appearance of the washwater being discharged from the filter during the washing process is shown by an improved type of clarity

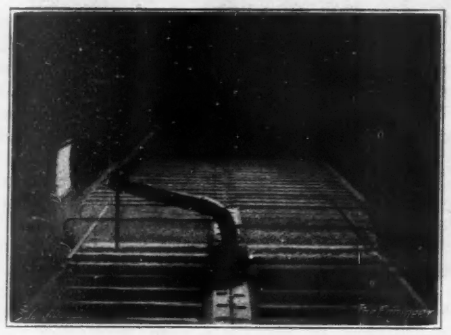


FIG 8—INTERIOR OF FILTER SHELL

indicator placed alongside the upwash valve to serve as a guide to the operator.

The filter shells are of riveted construction and have side access doors as well as top manhole covers. The base of the shell has mass concrete filling which supports the centre header with water laterals and the separate air laterals for the distribution of the air scour. The total depth of the filtering media is 3ft. 3in. In the engraving, Fig. 8, the interior of a filter is revealed with the sand bed removed. Air scour is provided by a rotary compressor in duplicate, each direct coupled to an electric motor and designed to apply the correct flow of air at the correct pressure, so that it has only to be switched on and off. On its way to the filters, the air is passed through dust and oil-eliminating filters, so that only pure, clean air is applied to the filter beds. The upwash is by reverse flow of filtered water from the main.

The final treatment is the application of a small dose of chlorine dispensed by a Candy chlorinator equipped with an automatic proportioning valve controlled by the main venturi tube. This valve maintains the rate of feed of chlorine proportional to the flow of water, and the measured flow of gas is then injected into the main in the form of chlorine solution by means of an hydraulic injector solutioniser. The motive power for the injector is provided by a rotary pump direct coupled to an electric motor. Both the chlorinator and the booster pump are in duplicate.

The electric power for the operation of the complete plant is supplied by a turbine-driven D.C. generator utilising the compensation water for its operation, and situated in a separate building.

The complete filtering plant was designed by the Candy Filter Company, Ltd.

The engineer for the whole of the Talybont scheme was Mr. W. W. Marsden, Engineer to the Corporation, and the contractors other than those already mentioned Gilbert Gilkes and Gordon, Ltd., of Kendall, for water turbines; Newport and South Wales Tube Company, of Newport, for pipes; and Glenfield and Kennedy, Ltd., Kilmarnock, for valves.

The Centenary Royal Show at Windsor

No. III

(*Continued from page 38, July 14th*)

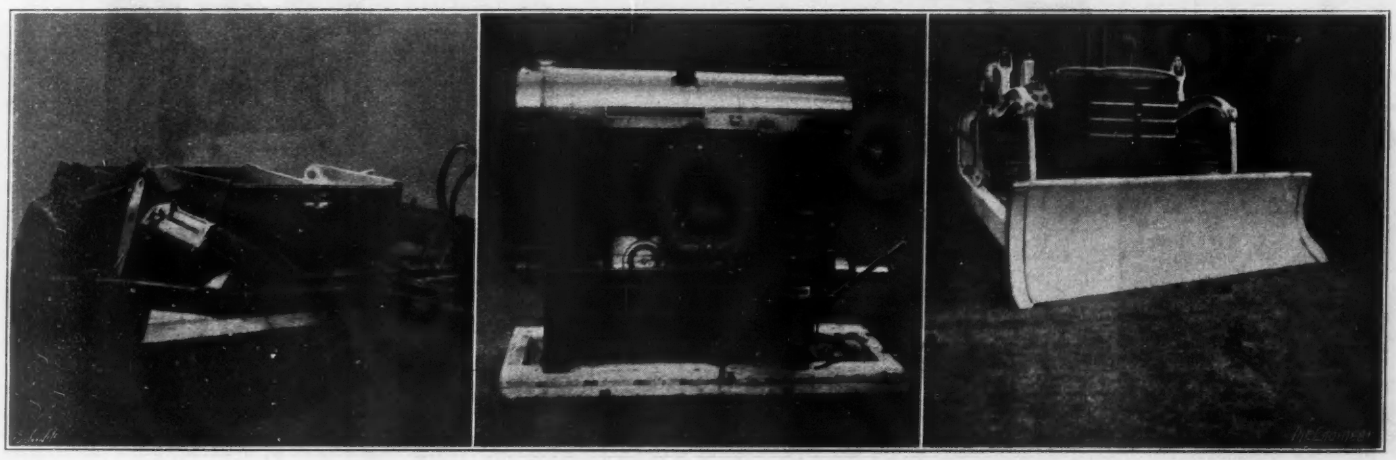
WE continue in what follows our description of the implements and other items of engineering interest which were on view at the recent Centenary Show of the Royal Agricultural Society of England held from July 4th to 8th in Windsor Great Park.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, LTD.

From the large number of exhibits shown by the International Harvester Company of Great Britain, of Harvester House, 259, City Road, London, E.C.1, which included harvesting, cultivating, and food-preparing machinery, tractors and farm wagons, we have chosen for illustration three exhibits which cover the wider field of industrial plants and contracting and civil engineering work. In Fig. 24 we show the Bucyrus-Erie two-wheel scraper which has hydraulic controls operated from a TD-40 International "Tractractor." The hydraulic control valve is mounted on the tractor and is of Bucyrus-Erie design, incorporating a relief valve which is designed to by-pass fluid automatically when 500 lb. pressure has been reached. The lever moves over a quadrant clearly marked with the "raise," "lower," and "hold" positions. By its use the body of the scraper can be held in any desired position. The frame of the machine is made in the form of a single member constructed of three annealed steel castings which are dovetailed together and welded, the end member forming a tongue or tractor hitch. All members are of box section, and the two side members carry the bronze-bushed bearings for the body pivot pin, and also the anchoring attachments for the hydraulic cylinders, and their links, by which the different positions of the bowl are obtained. The body is made of welded steel plates, a steel blade support casting being welded to the body and forming part of the support for the bottom of the bowl. The hydraulic cylinders and their connecting-rods and links are arranged at the sides between the wheels and the body, and ball and socket oil connections from the cylinders to the frame are provided.

In order to load the scraper the operator moves his lever to the "lower" digging position, and the oil pressure acting on the two cylinders forces the digging blade downward. The depth of stroke can be regulated by the operator, who then raises the bowl by moving the lever into the "raise" position. That movement is obtained by admitting oil into the opposite end of the cylinders. To dump the load, oil is again admitted into the anchored end of the cylinders, and as the bowl is tipped backward the chains controlling the action of the door tighten and move the door upwards and outwards, the amount of door opening being controlled by adjusting the length of the chain. The scraper has a cutting edge width of 5ft. 4in. and is mounted on two wheels with 10·5in. by 20in. pneumatic tyres, the digging depth below the tyres being 9½in. The ground clearance in the hauling position is 8½in. The machine has an overall length, including the tractor hitch, of 14ft. 5in., an overall width of 9ft. 8in., and an overall height in the hauling position of 4ft. 3in. It weighs about 7300 lb. and has an actual capacity of 3·94 cubic yards with a capacity when heaped to 30 deg. of about 5·0 cubic yards. The tractor shown with the scraper was the TD-40 model, which weighs when supplied with a standard tread, 12,400 lb.; with a wide tread, 13,000 lb., or with a rigid track frame, 12,720 lb. The four-cylinder, compression-ignition engine has 4¾in. diameter cylinders, with a stroke of 6½in., the designed running speed being 1100 r.p.m. The maximum belt horse-power is 50·73 B.H.P. at 535 r.p.m., and the maximum draw-bar horse-power in third speed is 44·68 H.P. With the engine running at 1100 r.p.m. there are five forward speeds of 1·74, 2·19, 2·74, 3·17, and 3·98 m.p.h. for the first to fifth speeds, respectively, and a reverse speed of 2·19 m.p.h. The length of tracks in contact with the ground is 70in., which, with a standard track width of 16in., gives an area of total contact of 2240 square inches. The overall length of the tractor is 140in. It has a width of 63¾in., and a total height of about 82¼in. to the top of the air cleaner. The tractor has a turning radius of 7ft.

The International power unit model U-10,



FIGS. 24, 25 AND 26—3½-CUBIC YARD SCRAPER, 45 B.H.P. POWER UNIT, AND TRACTOR WITH BULLDOZER—INTERNATIONAL HARVESTER

which we show in Fig. 25, is one of a series of power units built in twelve sizes with a range from 22½ to 100 H.P. maximum or 18 to 88 H.P. when running at continuous load. The smaller units have four-cylinder engines, and the larger six-cylinder engines. The U-10 model has a four-cylinder petrol engine with 4¼in. bore cylinders and 5in. stroke. The designed output at a governor rating of 1200 r.p.m. is 45 B.H.P. maximum or 36 B.H.P. at constant load. A 12in. belt pulley with an 8¾in. face is provided, the power output being controlled through a 12in. diameter clutch. The engine is mounted on a rigid foundation, and is complete with its pressure lubricating system and radiator cooling, the whole unit being neatly enclosed in a case with removable inspection doors. The same model can be supplied for paraffin fuels or for gas fuel.

The third exhibit, illustrated in Fig. 26, was a TD-18 "Tractractor," with a Bucyrus-Erie bulldozer. The tractor is generally similar in design to that already described, but it is driven by a six-cylinder engine having a bore of 4¾in. with a stroke of 6½in., the designed output at 1200 r.p.m. being 80 belt horse-power and 70 draw-bar horse-power. There are six forward speeds from 1½ m.p.h. at the first speed to 5¾ m.p.h. at the sixth, and the high and low reverse speeds are 1½ and 3¼ m.p.h., respectively. The length of the tracks on the ground are 84¾in. and their width 18in., giving a total area of ground contact of 3046 square inches. The tractor has a length of 158in., a total width of 82in. standard, and 94in. wide tread, and a total height of 93in. to the top of the exhaust pipe. It weighs about 21,500 lb. as a standard track machine, or 22,000 lb. when fitted with wide tracks. Both the TD-40 and TD-18 tractors are designed to use heavy fuel. There are two Bucyrus-Erie bulldozers, designed for operation with the TD-18 tractor, one with a blade length of 9ft. 2in., and the other with a blade length of 10ft. 2in. for use with standard and wide tracks. The blade height is 48in. The hydraulic controls, which are operated by cylinders in a similar way to the scraper, only at a lower pressure of 350 lb. provide for the lifting of the blade to a height of 34in. above the ground or lowering it to 12in. below the ground. The overall length of the machine, which is mounted so that the tractor is within it with the blade at the front, is 15ft. 8in., the overall widths of the standard and wide track machines being 9ft. 2in. and 10ft. 2in., and the weights about 7200 lb. and 7400 lb. A series of two scrapers, one with two wheels and one with four wheels, also two bullgraders, are built by the Bucyrus-Erie Company to operate with this tractor.

J. AND H. MCLAREN, LTD.

In view of the recent correspondence in our columns with regard to the rival merits of steam and oil-engine-driven ploughing tackle, it was of interest to inspect on the stand of J. and H. McLaren, Ltd., of Midland Engine Works, Leeds, one of the firm's latest oil-engine-driven cable ploughing and cultivating tackles. The principal difference between the new model and the earlier types is the fitting of an engine of the McLaren-Ricardo design, which is a four-cylinder unit with a designed output of 100 B.H.P., some 20 B.H.P. higher in power than the engines which were fitted in former McLaren ploughing units. For work in conjunction with these windlass engines there was shown the firm's six-furrow balance plough, and also a nine to eleven-tine cultivator.

Other exhibits included two and four-cylinder oil engines of the McLaren-Ricardo type embodying the Ricardo "Comet" Mark III patented cylinder head.

The general arrangement of the cable ploughing unit will be clearly seen from the engraving we reproduce in Fig. 27. It is mounted on a strong steel frame, formed of braced steel channels which is carried on four road wheels. The front wheels are ribbed in order to give efficient steering, while for the rear wheels cross plates are provided for adhesion. When working in difficult or boggy land, spudlets are fixed to the driving wheels, and angle iron rings to the front wheels, to prevent side-slipping when passing over greasy ground, while widening rings of various widths are also available should more adhesion be needed.

The front wheels are turned by a simple chain steering gear and the rear wheels are driven by worm drive through a differential gear giving facility in turning. The main engine is mounted at the front of the frame, and starting is made easy by fitting a small petrol engine. The engine is of the twin-cylinder, water-cooled pattern, and it is coupled to the main unit through a clutch and reduction gear. The other accessories which are mounted on the frame include the fuel tank, with its fuel transfer pump, a radiator, fan with cowling, and a water circulating pump. In addition to the main supply of fuel oil, a small quantity of light Diesel oil or paraffin is carried in a small compartment in the main fuel tank. Either fuel can be obtained by turning a three-way cock.

When driving machinery by belt the drive is taken from an extension of the engine crankshaft through a friction clutch. The same clutch also controls the ploughing and travelling gears, which are mounted at the rear end of the unit, overhanging the back axle, an arrangement which enables a shorter wheel base to be obtained with a corresponding saving in weight. The drive to the travelling and ploughing gears is by chain with sliding pinions for each gear. The road gear operates through a set of bevel pinions and bevel wheel driving a vertical shaft on which the worm drive to the differential gear and the road wheels is mounted. Both the winding gear and the road gear are fitted with a locking arrangement which makes it impossible to engage more than one gear at a time. The windlass is equipped for either wire rope or chain working, and there are available eight or nine different drum speeds, so that it is possible to work every type of land and to cultivate even the heaviest soils at an appropriate speed.

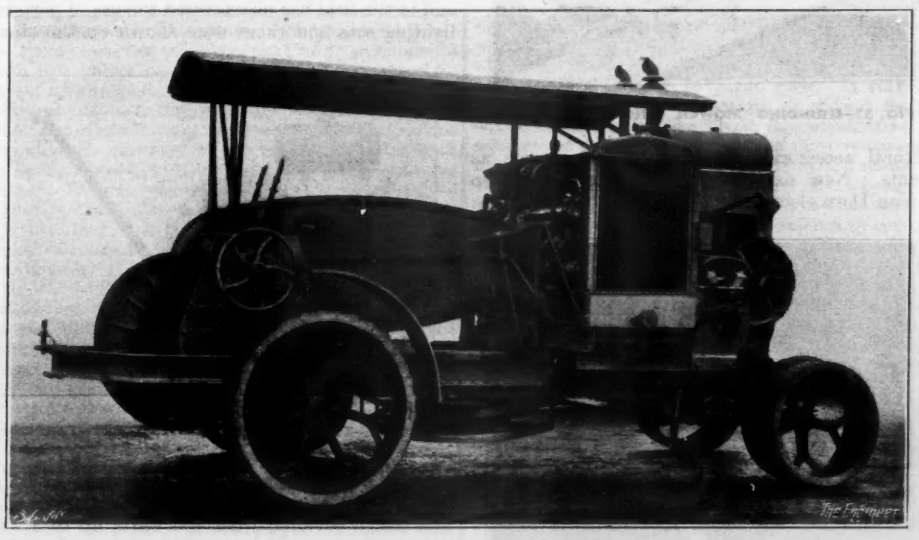


FIG. 27—OIL ENGINE-DRIVEN WINDLASS FOR CABLE PLOUGHING TACKLE—MCLAREN

MARSHALL, SONS AND CO. (SUCCESSORS), LTD.

A prominent exhibit on the stand of Marshall, Sons and Co. (Successors), Ltd., of Britannia Iron Works, Gainsborough, was a series of the latest model "M" tractors, one of which is shown in Fig. 28. The exhibit arranged to demonstrate the use of these tractors for various classes of work. Different types of pneumatic tyres were shown, and special features included the new locking device for improved wheel adhesion, enabling the differential gear to be locked instantly, so that the slip of a single wheel is thereby arrested. Medium and large size tractor winches were also on view. An important item in the firm's manufacturing programme is the decision to adopt one type of engine for a variety of machines, thereby making engine units and spare parts more easily available. The tractor engine has been chosen for this purpose, and it was shown also in the road roller, the dumper, and the power unit, all of which have at one time or another been described in our pages. The engine is of the horizontal, single-cylinder, two-stroke design, working with airless injection of fuel, and the fuel consumption is given as about 0·48 lb. per brake horse-power-hour, which, when ploughing on heavy

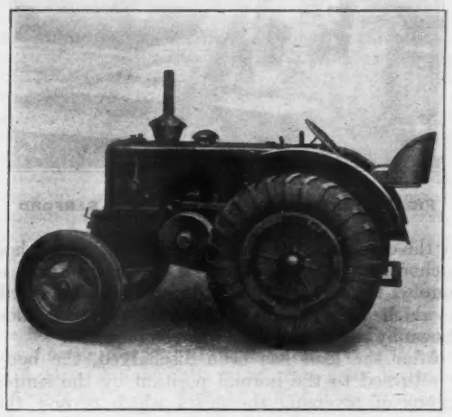


FIG. 28—TRACTOR—MARSHALL

lands, works out at approximately ¾ gallon per hour. The working speeds are 2·2, 3·1, and 5 m.p.h. forward, and 1·75 in reverse. When desired for working with pneumatic tyres, the top gear can be arranged for speeds of 7 or 9 m.p.h. The belt drive is taken from a 15in. diameter pulley with a 6½in. face running at a speed of 700 r.p.m. In the accompanying engraving we show a tractor mounted on pneumatic tyres. The front wheels are fitted with 6in. by 19in. tyres, and the rear wheels with 11·25in. by 24in. giant low-pressure pneumatic tyres. The tractor has an overall length of 9ft., a width of 5ft. 4in., and a height to the top of the radiator of 4ft. 6½in. The turning circle is approximately 9ft. 6in., and the ground clearance 1ft. With pneumatic tyres the tractor weighs 4950 lb.

In addition to the engined units above mentioned, two examples of Marshall threshing machines embodying the latest practice were shown.

AVELING-BARFORD, LTD.

From the wide range of road and garden rollers, and dairy equipment, which was to be seen on the stand of Aveling-Barford, Ltd., of Invicta

FIG. 29—3-CUBIC YARD DUMPER—AVELING-BARFORD

Works, Grantham, we have chosen for description and illustration the latest pattern of dumper for farming and contracting work. It is fitted with a four-cylinder petrol engine. While we have noted this machine on previous occasions, interest attaches this year to the new principle of tipping

gear, for which letters patent have been recently granted. A general view of the dumper is given in Fig. 29, and in Fig. 30 we show a view of the very robust gearing, while in Fig. 31 a diagrammatic drawing of the tipping gear is reproduced. As will be seen from the drawing, when the foot brake is applied, the brake shoes *f* tend to rotate round the axle, together with the plate *j*, to which the shoes are anchored. The movement thus given is possible within certain limits, provided that the body of the dumper is at the same time released

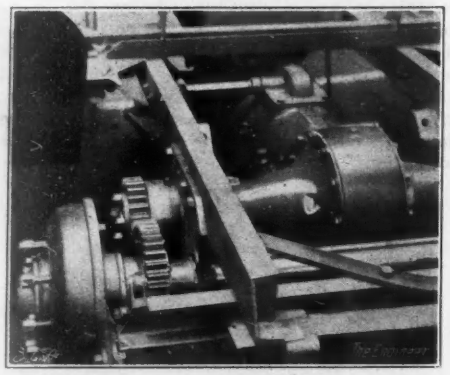


FIG. 30—DUMPER GEARING—AVELING-BARFORD

by the catches *m*. Also attached to the brake shoe anchorage plate is an arm *k* which, in turn, is coupled to the body of the dumper at *e* by a link *l*, which pulls down the body to the position shown by the dotted lines when so required.

After the load has been discharged, the body is returned to the normal position by the simple means of reversing the gears which reverse the action of the brake. At the same time the body is locked by the catch *m* and the brake then acts in the normal manner, since the anchorage plate *j* cannot move. Particular care has been taken in designing the dumper to distribute the load equally. The front axle is fixed and it serves only to carry the weight of the load. The gear-box and its casing, also the shafts, are so

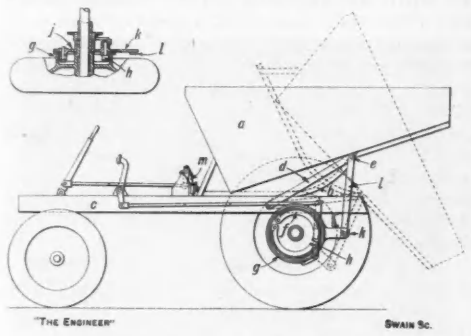


FIG. 31—DIAGRAM OF TIPPING GEAR —AVELING-BARFORD

disposed—see Fig. 30—that they are relieved from bending stresses, a construction which is particularly advantageous when working the dumper over heavy and rough ground.

JOHN FOWLER AND CO. (LEEDS), LTD.

One of the largest and most varied displays of oil engines was that on the stand of John Fowler and Co. (Leeds), Ltd., which firm also exhibits oil-engine driven Fowler crawler tractors and gyrotillers. We show in Fig. 32 two typical examples of the range of petrol and heavy oil fuel engines. Petrol engines were shown in seventeen different types, ranging in powers from 1½ up to 17 B.H.P., and with a range of speeds from 750 to 2000 r.p.m. The oil engines shown consisted of the Fowler-Sanders "D" series which are made in six sizes from 4 up to 16 B.H.P. They embody the firm's patented two-way swirl system of combustion, and the running speeds are from 750 up to 1500 r.p.m. A new feature, which we show in Fig. 32, is the full use made of the extended crankshaft on either side of the crank case, which allows of two fly-wheels and two belt pulleys being fitted. The fly-wheels and running parts are dynamically balanced and smooth running, which is important for transportable engines, is obtained.

A new model among the petrol units is the radiator-cooled model which is rated at 5 B.H.P. when running at 2000 r.p.m., which is also shown in Fig. 32 herewith. It has been designed particularly to the requirements of building contractors and for Home Office air-raid precaution work. Several of the larger sizes of engine were on view, and most of them were shown in actual operation. There were a number of the firm's "PA" series of petrol engines, and "D" series of oil

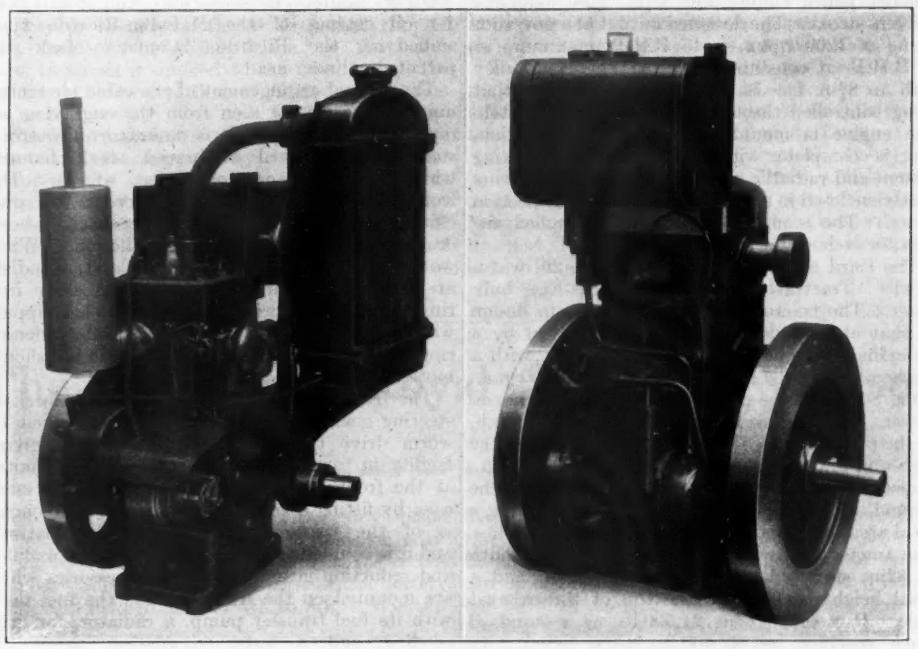


FIG. 32—5 H.P. PETROL ENGINE AND 6 H.P. OIL ENGINE—FOWLER

engines connected to pumps and dynamos, the largest generating set being one for 39 kW designed specially for showmen's use.

ALFRED HERBERT, LTD.

On the stand of Alfred Herbert, Ltd., of Coventry, there was shown a wide range of agri-

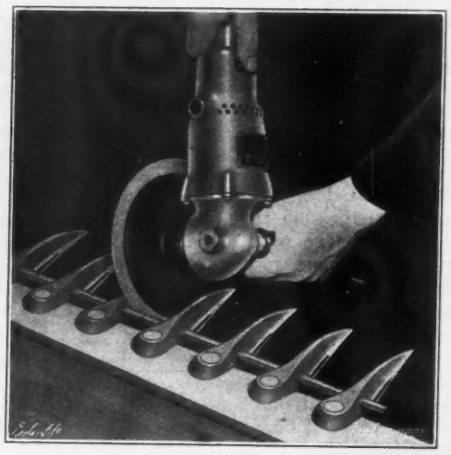


FIG. 33—GRINDING MOWER FINGERS—HERBERT

cultural accessories for which the firm acts as agents. New exhibits included the application of Van Dorn electrically driven tools to farm uses.

FIG. 34—GRINDING MOWER KNIVES—HERBERT

We illustrate in Fig. 35 a Van Dorn disc grinder specially designed for work in the field, and in Figs. 33 and 34 its use for grinding mower fingers and knives. The use of such a grinder greatly simplifies the maintenance of mower knives and fingers without having to take the finger bar to pieces and reassembling and aligning it. The flexible abrasive disc employed on the grinding tool enables the operator to grind both the cutting edge of the mower fingers and also the radius at the base of the finger. The surfaces of the finger can also be cleaned very quickly. For grinding

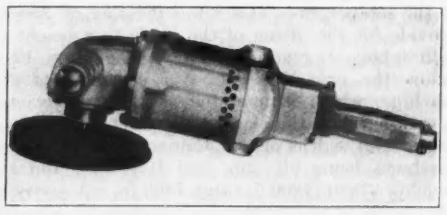


FIG. 35—PORTABLE GRINDER—HERBERT

fingers a medium grade of abrasive is recommended, while for sharpening knives a fine grade is used.

TARPEN ENGINEERING COMPANY, LTD.

The increasing use of electricity on the farm and in the field has necessitated the use of portable lighting sets and these were shown on the stand

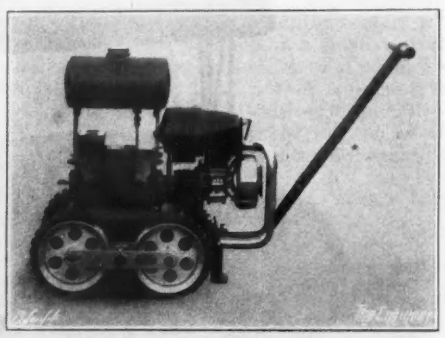


FIG. 36—400-WATT GENERATING SET—TARPEN

of the Tarpen Engineering Company, Ltd., of Ixworth House, Ixworth Place, London, S.W.3, in a range covering from 400 watts up to 3 kW. All the sets are mounted on fixed bases when they are required for stationary work, or, alternatively, they can be supplied fitted with pneumatic-tyred wheels in cases where the sets are required to be portable. The accompanying engravings show two of these sets. In Fig. 36 we illustrate one of the firm's 110-volt, 400-watt portable generating sets, driven by a 1 H.P. petrol engine, and mounted on crawlers comprising two wheels spanned by an endless rubber-treaded band having an elliptical section. It is claimed that with this type of wheel support the sets can be easily moved

over exceptionally rough ground. These sets can be supplied in larger sizes of 1 kW, 2 kW, and 3 kW output. Fig. 37 shows a combined pumping and lighting unit, also petrol engine driven, which is mounted on a two-wheeled frame with pneumatic tyres. In addition to generating sets, the firm exhibited a range of six sizes of pumping sets, also a special set, designed for fruit-tree spraying at pressures up to 100 lb. per square inch with a 30-gallon tank. For use with the electrical generating sets

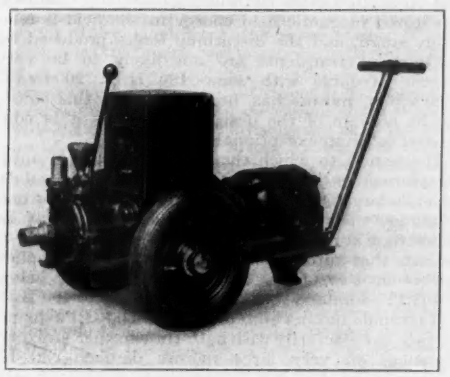


FIG. 37—PUMPING AND LIGHTING SET—TARPEN

there was demonstrated a number of interesting portable electric garden tools, which included electric saws, hedge trimmers, and light rotary grass trimmers for banks which cannot easily be cut by a large machine.

(To be continued)

Engineering Notes from China

(By Our Own Correspondent)

Inevitable Developments

FOR several years the writer has been privileged to contribute these Notes to THE ENGINEER. They were hitherto always written in geographical China, and in most cases in the British Colony of Hong Kong. This contribution is being compiled during the voyage "home" after retirement.

The regulations of the University have compelled the writer to vacate the Taikoo Chair of Engineering in Hong Kong after twenty-seven years of service. When, in 1912, a cable from Hong Kong was received in London offering the appointment, the first reaction was the impulse to refuse. But at that time the writer was in fairly close contact with Sir Alfred Ewing, who had persuaded him to undertake the most tedious and perhaps the most difficult task experienced during an active professional career. Sir Alfred had suggested that "The New Steam Tables" based on Callendar's researches and Mollier's work should be compiled. An old student, A. G. Warren, agreed to co-operate in making the many and lengthy calculations, and Sir Alfred said that he would write an introduction. The tables have been out-of-date for some years, but they were the first to be published with new values based on Callendar's researches for steam up to 300 lb. pressure per square inch. They were calculated as suggested by Mollier and Ewing. The chief credit for any merit in the fact that no one disputed the accuracy of the tables—compiled both in lb.-Fahrenheit and lb.-Centigrade units—was due to A. G. Warren, who was for years a colleague of the writer in the University of Hong Kong. But it is worth noting that Ewing made a large number of check calculations before he supplied the very useful introduction in 1912.

It was while Ewing was at the Admiralty that he made these many check calculations; in the midst of his careful consideration of our new steam tables the cable from Hong Kong was received. His advice was sought. He immediately urged acceptance. Looking back over the period 1912–39, the writer is grateful to Ewing for his persuasive words, for it has been worth while to train Chinese engineering students in British standards; and not only in British engineering standards, but in British standards concerning co-operation and general conduct. Moreover, the study of the engineering works and problems in China, the gradual growth of the conviction that vast technical developments are inevitable in that country, and the belief that Anglo-Chinese co-operation is essential for stable political conditions in the Far East, are subjects that have provided an interesting intellectual occupation during the leisure hours that were not devoted to teaching, research, or administration.

Chinese Engineers

Every engineer who is proud of his profession is sure to be interested in its history in any part of the world. The ancient engineers in China constructed works—the Great Wall and the Grand Canal—unsurpassed in their class by those of any other nation. The Chinese claim to have supplied the world with the compass, paper, printing, and gunpowder. They have a saying that "China is a sea that salts all of the rivers that flow into it." No intelligent foreigner can spend most of his working life in close contact with the Chinese people without admiring many of their racial characteristics, and it must be acknowledged that the three million Chinese who are British subjects in Hong Kong, Malaya, and elsewhere, have always been law-abiding and industrious workers.

There are, in the Far East, nearly three hundred engineering graduates of the British University of Hong Kong; nearly all of them are Chinese. Among the characteristics of the race, the love of learning for the intellectual satisfaction so obtained, and the respect for the teacher, are traits that make the work of a university professor easy. There are Chinese engineers who graduated in Hong Kong more than twenty years ago. They frequently correspond with the writer, and it is hoped to be able to obtain in the future, as in the past from them details of the engineering work upon which they are engaged; so that a change of residence does not, of necessity, involve a complete break with technical developments in China. Anglo-Chinese co-operation transformed, within a century, a pirate's lair, with about 5000 inhabitants, in Hong Kong, into one of the largest shipping centres in the world, with a population of a million people. The British contributed technical plans and efficient administration, and the Chinese astonishing industry and enterprise. Similar co-operation has made Malaya one of the wealthiest and commercially important portions of the British Empire. Anglo-Chinese co-operation will have a profound influence in accelerating the inevitable transformation of the social and economic life of the Chinese people, and in that transformation the engineer has already taken, and will continue to take, a very prominent part.

Although this most numerous and ancient nation on earth are at present paying a terrible penalty for the blind opposition of their officials in the eighteenth and nineteenth centuries to the attempts made by foreigners to introduce mechanism and other scientific appliances into China, yet it must be realised that, not only is there now no opposition to technology in China, but there is a great anxiety in the minds of officials and intellectuals to obtain for their nation the benefits of modern scientific equipment and methods. The political changes that may take place in the Far East as a result of this terrible warfare cannot be foreseen, but it is a consolation to know that if the worst happens history teaches us that political changes in China are inevitably transient. The important result of the Japanese invasion is already apparent, viz., the acceleration of the progress of the introduction of mechanism in order to develop the natural resources of China. The final effect of this transformation of the social life of this industrious and intelligent race, by the utilisation of scientific knowledge, must be of benefit to other nations, for it is a fundamental axiom of the Chinese outlook on life that people should be governed by moral and intellectual agencies rather than by physical force. That is one of the axioms that have, for many centuries, formed the foundations upon which has been built a nation that has maintained intact a culture and a civilisation in its own country for forty centuries of authentic history. It is a civilisation that was remarkable before England was a name. It produced a great literature and splendid engineering works when ancient Britons were burning human captives as a sacrifice to pagan gods. It survived while the less stable civilisations of ancient Egypt, of Greece, and of Rome evolved, flourished, and then were swept away. It built up the most remarkable monument that exists on earth to-day; a nation of 450 million people, who are industrious, intelligent, cheerful, and essentially peaceful. The final effect of the application of technology and science in general, by the Chinese people, to aid their social and economic life, will be to weigh down the scales of international justice in favour of a peaceful solution of the disputes between nations. For although the Chinese are to-day sacrificing themselves in defence of their native land, they are essentially a peace-loving people, with a profound contempt for those who use physical force rather than discussion and compromise when any matter is in dispute. The new world civilisation created by the rapid progress of technology demands for its development international peace. It is encouraging to realise that any engineer who assists the Chinese to develop the natural resources of their country and so to assume a more prominent position in international affairs, is also at the same time assisting in the efforts made to substitute moral and intellectual agencies for physical force in the case of any dispute.

The Burma-Yunnan Road

A correspondent in London agrees that the completion of the motor road between Yunnan and Lashio must mean a considerable increase in trade between Burma and China, but he doubts very much whether any Burma-China railway link will be completed, as he believes that the motor roads will make it unnecessary. On the other hand, the Chinese engineer from Yunnan, who consulted the writer of these Notes in Hong Kong a few months ago, stated that a number of Chinese engineers were at work on surveys for a railway to the Burma border. There seems to be no signs of similar work being done in Burma.

An interesting comment by this traveller who made the journey from Bhamo to Tengyueh, and who is interested in electrical power production, is that there are some very large potential power sites on several of the great rivers in that part of Asia. Even at Tengyueh itself a small river, the Nani Ti, which drains a large part of the Tengyueh plain, falls over a hundred-foot cliff, and a series of steep rapids within a mile of the city wall. My correspondent adds that it "provides one of the easiest power sites for development I have ever seen."

There can be no doubt that there are a large number of sites in China where it would be comparatively easy to transform the "white coal" into electrical energy. The plans need to be carefully prepared by expert engineers, so that the plant originally installed may not be out of proportion to the probable load, and so that extensions may be made in an economical manner. The main difficulty in past years has been concerned with the transport of machinery which had to be carried hundreds of miles on the backs of coolies over mountain ranges. It requires no great imagination on the part of any engineer, who studies the data available concerning the rivers of China, to enable him to visualise a future when there will be numerous hydro-electric plants gradually building up a load which may total, within the lifetime of the Chinese undergraduates studying engineering to-day, some millions of horse-power. But the initial installations must not be planned on a grandiose scale. That is a mistake that has been made in the case of some of the projects that have failed in China.

In two issues of this journal (December 23rd and 30th, 1938) the writer contributed a description of the difficulties connected with this new road. There can be no doubt that the road and the railway from the far interior provinces of China to the port of Rangoon will, at no distant date, be of great value to British interests in China. Already British firms are benefiting by this new line of communication with the interior provinces.

Magnificent and Exciting

Only a few weeks ago an Englishman journeyed over the 725 miles of highway from Lashio to the city of Yunnanfu (now officially named "Kumming"). There were, in the old days of caravan traffic, over a thousand small wooden bridges between Kumming and the Burmah frontier. These, since the beginning of 1938, have been gradually replaced by stone structures; the larger bridges were reconstructed with stone foundations and wooden beams sufficiently strong to carry 10-ton loads. Steel cable suspension bridges span the Mekong and Salwen rivers and can carry 7½-ton loads. Steel cables have often replaced the old style bamboo ropes.

The section between the Burma frontier and Shakwan in the western part of the province of Yunnan is 345 miles in length. It was commenced in December, 1937, and was opened to motor traffic in the following November—an astonishing accomplishment when it is realised that the road passes over many high mountain ranges and several wide rivers. There are differences of over 4000ft. between the mountain passes and the river valleys in some places. The maximum height above sea level of the road is 8500ft., and about 140 miles from that point is a most extraordinary dip, where the road falls in a zigzag manner from a height of 7200ft. to 2500ft. At the lower level it crosses the Salwen River by means of a suspension bridge. It then begins another steep and winding ascent to a height of 7500ft. That height is but little above the average elevation of a considerable portion of the road, and vehicles at times run above the clouds. It is said that the picturesque grandeur of the scenery visible during this high-level journey is unsurpassed. One traveller, who followed the old route taken by caravans, said that as he journeyed over mountain passes and down to the river valleys his up-and-down movements were like those of an ant crawling over a sheet of corrugated iron.

It is amazing that, although there were 200 Chinese engineers and about 170,000 workmen engaged on the highway, it was constructed in such a rapid manner, especially as there was available no modern road-making equipment. There are dangerous stretches, with numerous sharp curves and steep gradients, but the road has carried vehicles loaded with petrol, munitions, &c. The Chinese will take chances that few, if any, Europeans would take. Landslides are frequent, but labour is available to clear the road, and the delay is accepted with Oriental patience.

It is said that it is dangerous to attempt an average speed of more than 20 m.p.h. for the whole journey of 725 miles, and as driving in the dark is too hazardous, the shortest time practicable for a car to cross the route is about four days. There was some difficulty with the Burma Government concerning transit duty, which in February last was calculated at above £112,500 on the 16,000 tons of supplies for China which had accumulated in Rangoon. Another difficulty for transport is the heavy rainfall in Western Yunnan, which begins at the end of May and lasts

until the end of October. It averages the very high figure of 208in. for that period. Chinese engineers and workmen have been instructed by the Chinese Government to continue to improve the road after its completion. The plan is to widen the road bed to a minimum width of 9 m., where the foundation is of earth, and to 7 m. where it is of rock. It will take some time, but a reliable Englishman, long resident in Rangoon, recently informed the writer that he agreed with the Chinese engineer, who said that in 1940 some hundreds of miles of this road would be a speedway for cars. The opening up of inland Chinese provinces, especially the province of Szechwan, which is in area 155,813 square miles (much larger than the whole of the British Isles), will have remarkable economic results. It must be stated that the completion of the Burma-China highway is an historic event and its construction is a remarkable achievement reflecting the greatest credit upon the Chinese engineers engaged upon the task. It is impossible to praise too highly the initiative, the courage, and the iron determination of these engineers who have accomplished what many travellers said was impossible. They have triumphed over the intricate and perilous topographical obstacles which have dismayed more experienced engineers. They have organised an enormous labour force, which carried on difficult and dangerous work with primitive tools. It is probable that in the history of China that will be written in the years to come the construction of this road will be considered an engineering triumph equal to, or even greater than that of the building of the Grand Canal some centuries ago. It reinforces our confidence in the ability of the modern Chinese engineers, and the Chinese workmen to carry out engineering schemes of great magnitude.

Auto-Transformer Started Squirrel-Cage Motors

AN investigation carried out some little time ago by the Metropolitan-Vickers Electrical Company on the auto-transformer starting of squirrel-cage motors is described by Mr. D. B. Hoseason in a paper he read before the South African I.E.E., and published in the June issue of the firm's *Gazette*. The investigation was undertaken in consequence of the failure of a 900 H.P., 1460 r.p.m., squirrel-cage mine pump motor, having a contactor type auto-transformer. Failure was attributable to distortion of the field coils, which, although they might have been more adequately braced, showed far more distortion than would be expected from the currents measured on the ammeter. Evidence tended to show that mechanical forces were occurring in excess even of those experienced with direct switching.

A preliminary test in the factory taken with the oscillograph on a very much smaller motor, showed that under certain conditions transient currents between twenty and thirty times full load current may occur at the instance of changeover from the starter tap position to the running position. This test led to a thorough investigation and the results are shown in the oscillograms, Figs. 1 to 4.

After switching an induction motor off the line, the die-away curve of stator voltage is that shown in Fig. 1. In the case of this machine, appreciable voltage exists at the stator terminals for some three seconds, after tripping the machine off the line. In the absence of the short-circuited rotor, the magnetic field in the motor would collapse immediately and the energy corresponding to it would appear as a spark at the switch contacts. But on account of the short-circuited rotor winding, the tendency of the field to collapse establishes a D.C. in these windings, which tends to maintain the field and incidentally allows the starter to be opened with little or no arcing at the contacts. To enable the behaviour of the rotor current to be observed, a test was carried out on a slip-ring machine, and the results are shown in Fig. 2; whilst the results of a further test in which the rotor circuit was opened almost simultaneously with the breaking of the stator current are shown in Fig. 3, where it will be seen that, as might be expected, there is immediate collapse of the magnetic field and terminal voltage.

The phenomena shown in Fig. 1 are similar to those experienced with a salient pole synchronous motor, with the exciter coupled to the machine, and remaining in circuit during the shutting-down period. D.C. is flowing in the rotor windings, a magnetic field exists, and there is an appreciable voltage at the stator terminals. With auto-transformer or star-delta starting, this means that when the starting handle is moved from the "start" to the "run" position, during the interval when the machine is disconnected from the line, the phase position of the stator voltage may shift with respect to the supply voltage and on reclosing the circuit the conditions are similar to switching on to the bus-bars without synchronising.

In Fig. 4 is shown the effect of repeated switchings.

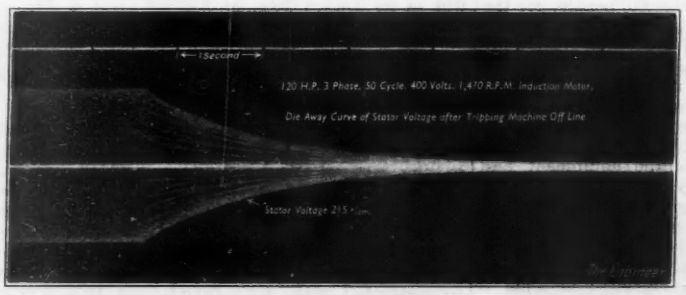

1 Second
120 H.P. 3 Phase, 50 Cycle, 400 Volts, 1,470 R.P.M. Induction Motor.
Die Away Curve of Stator Voltage after Tripping Machine Off Line
Stator Voltage 215 r.m.s.

FIG. 1—DIE-AWAY CURVE OF STATOR VOLTAGE

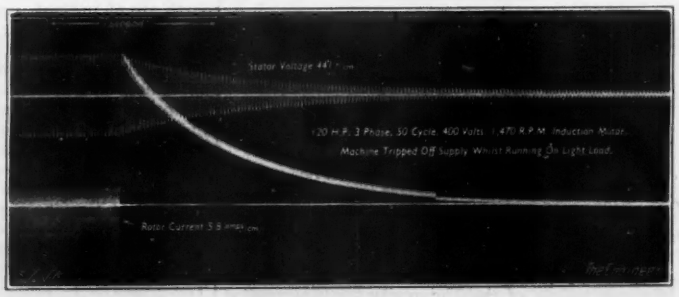

Stator Voltage 447 r.m.s.
120 H.P. 3 Phase, 50 Cycle, 400 Volts, 1,470 R.P.M. Induction Motor.
Machine Tripped Off Supply Whilst Running On Light Load.
Rotor Current 5.8 amps r.m.s.

FIG. 3—STATOR VOLTAGE AND D.C. IN ROTOR

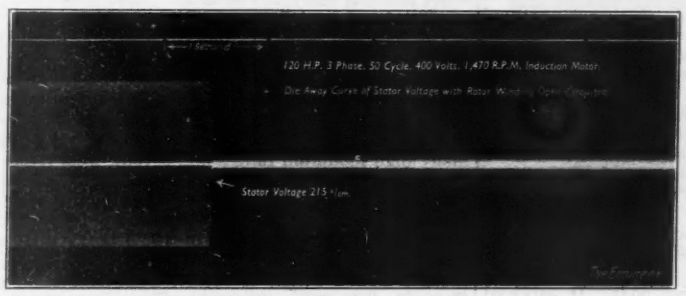

1 Second
120 H.P. 3 Phase, 50 Cycle, 400 Volts, 1,470 R.P.M. Induction Motor
Die Away Curve of Stator Voltage with Rotor Winding Open Circuited
Stator Voltage 215 r.m.s.

FIG. 3—STATOR VOLTAGE WITH ROTOR CIRCUIT OPENED

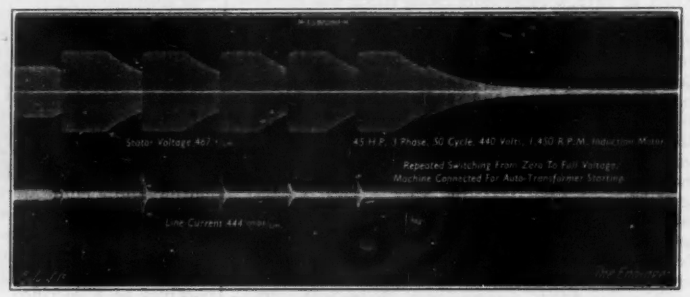
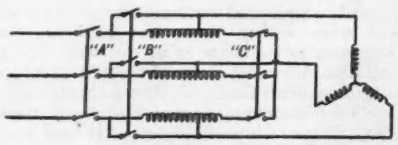

Stator Voltage 467 r.m.s.
45 H.P. 3 Phase, 50 Cycle, 440 Volts, 1,430 R.P.M. Induction Motor
Repeated Switching From Zero To Full Voltage.
Machine Connected For Auto-Transformer Starting
Line Current 444 amps r.m.s.
1 Sec

FIG. 4—CURRENT SURGES WITH REPEATED SWITCHING



Step 1. "A" Closed, "B" Open, "C" Open.
Step 2. "A" Closed, "B" Open, "C" Closed.
Step 3.(a) "A" Closed, "B" Open, "C" Open (Momentarily)
Step 3.(b) "A" Closed, "B" Closed, "C" Open.

"THE ENGINEER" SWAIN Sc

FIG. 5—KORNDORFFER STARTING METHOD

The 45 H.P. motor was started up on the tap position, and then switched on to the full voltage for approximately one second. The starter handle was then allowed to fall back into the neutral position for about half a second, and the motor was then reclosed on to the line. As shown by the oscillogram, the operation was repeated several times. In the first two cases the motor was evidently in phase with the supply voltage, when the circuit was reclosed, but in the last four instances the machine was badly out of phase. On the two final switchings the oscillograph element moved completely off the scale. The current surge exceeded in these two instances twenty times full load current. The same phenomena naturally occur with star-delta starting, or with any system in which the motor is disconnected from the line for a short period and then reconnected. Whenever auto-transformer or star-delta starters are employed these phenomena occur on all sizes of machines. But on small motors the windings are very compact, the stored magnetic field energy in the field is relatively small, and the disturbing forces produced by the current transients are not likely to be very severe. Trouble with some 180 H.P., 2000-volt, 2950 r.p.m. motors has been traced to this cause, but on account of the design of the coils it is considered to be an exceptional case.

The extent to which the normal method of auto-transformer starting can be applied with safety depends largely on the dimensions of the stator end windings, their inherent stiffness, and the way in which they are braced. Practical experience seems to indicate that auto-transformer starters can be applied safely on two, four, and six-pole motors below 250 H.P. Similarly, eight-pole motors up to 400 H.P. and ten-pole motors and over up to 500 H.P. should operate satisfactorily with auto-transformer starters. Although on very large motors damage can be minimised by bracing, no amount of bracing will withstand indefinitely shocks repeated possibly two or three times a day. Although alternators are braced to deal with short-circuit] transients of the kind described, they are only called upon to do so in the case of emergency and at wide intervals of time.

The Korndorffer method of starting, shown in Fig. 5, effectively eliminates transients. On the last step of this starter the star point of the auto-transformer is opened a very short time before the switch B is closed, short-circuiting the transformer and connecting the motor windings directly to the supply. In some cases the first step in which the star point of the auto-transformer is opened and the transformer windings act merely as series chokes is omitted and the equipment is closed on the line with the star point made. The motor then accelerates on the tap position of the auto-transformer. An alternative method of starting is to employ series chokes and to short-circuit them when the motor is up to speed. The torque available for a given current drawn from the supply is not, however, so large as that obtained with the Korndorffer method.

Not only are the motor windings subject to the large transient currents described, but the stator contacts also have to carry them, and incidentally, since the circuit is usually in the process of being closed, the actual contacts are sliding over one another at the time the transient takes place, and are therefore in a very unsatisfactory condition to stand up to the arcing. Moreover, the auto-transformer windings and leads must withstand the mechanical shock. No doubt failures that have occurred on these parts in the past have been attributable to this cause. Relay and meter coils and mechanisms must also withstand the surge and as the mechanical forces vary as the square of the current, it is easy to appreciate why certain ammeter and relay movements have been occasionally damaged.

Rail and Road

NEW RAIL HALT AT UPTON-BY-CHESTER.—The London, Midland and Scottish and Great Western railways announce the opening of a new halt at Upton-by-Chester, between Chester and Mollington on the Chester and Birkenhead joint line, for passenger traffic, as from Monday, July 17th.

LONDON AND HOME COUNTIES TRAFFIC ADVISORY COMMITTEE.—The London and Home Counties Traffic Advisory Committee has been reconstituted under the provisions of Sec. 58 of the London Passenger Transport Act, 1933, for a period of three years from July 1st, 1939. At the first meeting of the new Committee on July 5th, 1939, Sir Harry Vanderpant, the representative of the Westminster City Council, was unanimously elected to the chair.

BRIDGE OVER THE SEVERN.—Although in February the Government was prepared to make a grant of 75 per cent. towards the cost of a further investigation as to the best means of crossing the River Severn by bridge or tunnel below Gloucester, it has now been decided, states the Minister of Transport, Captain Wallace, that the Government is not at present prepared to contribute towards the cost of such a crossing, in view of the need of concentrating the financial resources of the country upon its more urgent requirements.

ROAD VEHICLES IN GREAT BRITAIN.—A return has been issued by the Ministry of Transport giving the numbers of mechanically propelled road vehicles registered for the first time under the Roads Act, 1920, during the month of May, 1939. The total number of new vehicles registered was 45,600, compared with 37,583 in May, 1938. The total number of motor vehicles licensed at May 31st, excluding tramcars, vehicles requiring trade licences, and vehicles for which exemption from payment of licence duty has been granted, was approximately 3,044,861, compared with 2,906,993 at May 31st, 1938.

NEW RAIL SPEED RECORD.—A new record for rail vehicles was set up recently in Germany when a maximum speed of 134 m.p.h. was attained by a new three-car train, the "Flying Silver Fish," on the Hamburg and Berlin line. The train is equipped with two Maybach exhaust gas pressure-charged 600/650 H.P. oil engines, driving through Fottinger-A.E.G. hydraulic torque converters. It is claimed that the train offers little air resistance, and is quiet, even at full speed. Seating accommodation is arranged for 100 passengers. The train weighs 113 tons empty. On the occasion of the record run the average speed was 125 m.p.h.

NEW EXPRESS LOCOMOTIVES FOR THE L.M.S.—The London, Midland and Scottish Railway has just put into traffic, following its completion at the Crewe works, the "City of Birmingham," "No. 6235," the first of twenty large new streamlined locomotives which are being constructed this year and which are to be named after cities on the L.M.S. system. These locomotives weigh in working order 164 tons, are nearly 74ft. long, and are painted the standard L.M.S. red, with horizontal gold bands. After being run in, they will be used for hauling the heaviest and fastest expresses on the system. Their tenders hold 10 tons of coal and 4000 gallons of water.

WORLD'S FAIR RAILWAY ARRANGEMENTS.—The Pennsylvania Railroad, which serves an area containing half the population of the United States, has built a special station near the centre of the World's Fair, and is running a continuous shuttle service of electric trains every few minutes to and from the Pennsylvania Station, New York, starting at 9.10 a.m. and ending at 3 a.m. In order to solve the problem of handling great crowds, the railway has designed a special station which is said to be capable of receiving 20,000 passengers an hour. During the first fifty-one days of the Exhibition 8581 outward and inward trains were run, carrying 3,455,453 passengers, a figure which is said to be about a quarter of the total of visitors who have been to the Fair.

"ONE-WAY" TRAFFIC SCHEMES.—It is announced that further "one-way" traffic schemes are proposed in the London Traffic Area, and subject to any representations that may be received, regulations will be made accordingly. The roads affected are:—In Wembley, at the junction of (*a*) Wembley Park Drive and Empire Way, and (*b*) Bridge Road and Forty Avenue; in the interests of safety, it is proposed to introduce a scheme of roundabout traffic working at the junction of Wembley Park Drive and Empire Way. In addition, a scheme of "one-way" traffic working is proposed in the slip road at the junction of Bridge Road with Forty Avenue. In Westminster, in Trebeck Street and Hertford Street; "one-way" traffic working is proposed in Trebeck Street from north to south and in Hertford Street from south to north.

LONDON TRANSPORT CENTRAL LINE.—On July 12th Driver H. T. Daniels drove on its last journey the last train of old type left on the London Transport Central Line. The guard was M. E. Bowler. In the Wood Lane depot, Driver D. Bullard drove on its last day of duty an electric locomotive which had been retained for shunting work from the days before multiple-unit stock was introduced. Both the train and the locomotive are about forty years old. It is believed that at least one of the cars—since modernised and fitted with automatic doors—was included in the train which King Edward VII, as Prince of Wales, drove at the opening of the railway in 1900. The train now withdrawn is the sole survivor of forty-five trains of old type which have been taken out of service gradually since September of last year. Their replacement by standard tube stock marks an important stage in the reconstruction and modernisation of the Central Line. The programme consists of realigning the tunnels, lengthening the platforms to accommodate longer trains, replacing the running rails with the standard British type of rail, and installing a fourth current rail. This work is being completed rapidly. Chancery Lane and St. Paul's stations have been rebuilt; Liverpool Street and Notting Hill Gate stations are being reconstructed. The next step is to resignal the line. Soon the old Central Line will be able to take more and longer trains in readiness for the extension to Ruislip in the west and Ongar in the east.

Miscellanea

OBSERVATORY FOR UPPINGHAM.—At the Speech Day, Mr. J. F. Wolfenden, headmaster of Uppingham, stated that the school is to have an observatory which the boys will help to construct. The late Mr. G. L. Brook had left the school a considerable quantity of astronomical instruments and a powerful telescope, which would be installed in the proposed observatory.

SPECIAL AREAS IN SCOTLAND.—Lord George Nigel Douglas-Hamilton, Commissioner for the Special Areas in Scotland, announces that during June he has entered into commitments amounting to about £10,500 for the further economic development and social improvement of the areas. Of this sum about £5000 was for a waterworks, estimated to cost about £8500; about £1500 for a sewage works, estimated to cost about £3800; and the bulk of the remainder to pay for increases in the estimates for public works already in hand.

OIL PROSPECTING IN ENGLAND.—The Anglo-American Oil Company, Ltd., which has already done exploration work in Scotland, where three oil wells have been sunk, two of which are now producing, is carrying out an exhaustive survey of the oil prospects further south. Four new licences have been granted to search for oil in Lancashire and considerable drilling is going on in North-East Yorkshire, holes being sunk to determine the nature of the strata. This month a survey will be begun with the aid of an instrument known as a "gravimeter," which indicates structural qualities in the earth by measuring the pull of gravity over the areas concerned.

LARGE LATVIAN POWER WORKS.—The large power plant at Kegums, in the Düna River, Latvia, on which work has been going on since 1936 under direction of Swedish engineers, is now nearing completion. It is expected that trials with the plant may take place in October next. Two Kaplan turbines have already been installed, and the installation of the generators is rapidly progressing. The transmission line from Kegums to Riga has been completed. The plant, on which at present about 1500 men are at work, has been built for the Latvian Government by Svenska Entreprenad A/B, and the total cost of the plant and transmission lines is estimated at about 55 million kroner.

WATER POWER IN CANADA.—Nearly 88 per cent. of Canada's total hydraulic development is installed in central electric stations, representing more than 95 per cent. of the main generating equipment in that country. This equipment generates more than 98 per cent. of the total electricity produced for sale in Canada and for export. Practically all recent hydraulic installations have been carried out by central electric station organisations. In the ten-year period ending 1938, the central station installations increased by 2,756,566 H.P., as compared with an increase of only 84,974 H.P. for all other purposes. The last-named figure represents less than 3 per cent. of the total increase figures.

ONE HUNDRED YEARS OF PHOTOGRAPHY.—The Science Museum at South Kensington has arranged, in conjunction with the Royal Photographic Society and the photographic industry, an exhibition to illustrate the history of photography from the time of its inception in 1839 down to the present day. It will be open to the public for five weeks from Saturday, July 22nd. Divided into three main sections, the exhibition includes early apparatus and examples of the work of Niepce and Daguerre in France, and Fox Talbot, Herschel, and Scott Archer in this country; a second group deals with the development of pictorial photography and is illustrated by photographs from the collection of the Royal Photographic Society; in the third group are illustrated the many applications of photography to everyday life.

LOOMS WITHOUT SHUTTLES.—A new development in weaving machinery is claimed in the construction by two Soviet engineers of a loom in which the necessity for a shuttle in which to carry the bobbin is obviated. The loom they have invented is stated to be simpler in construction than the present-day type, as with the elimination of the shuttle a number of auxiliary parts, such as the picker, are also rendered unnecessary. In the new type of loom, which has been constructed by V. E. Leontiev and A. T. Yermichev, the bobbins can be changed while the machine is in motion, and owing to its simplicity of design stoppages through the breaking of warp and woof are eliminated, while provision is made for automatic stopping if anything goes wrong. In normal conditions the loom, it is reported, can run continuously for three or four days, even the halt for operator's meals being unnecessary. The first looms of this type are being installed at the Sobolevo-Shchelkovo spinning and weaving mill (near Moscow), where the constructors have been conducting their experiments.

LIGHTNING PROTECTION FOR TRANSMISSION LINES.—Transmission lines and stations can now be built in the United States virtually lightning proof. Speaking before the International Conference on Large Electric High-Tension Systems in Paris, June 28th to July 8th, 1939, Mr. P. L. Bellaschi, research engineer, Westinghouse Electric and Manufacturing Company, discussed the various improvements made in power apparatus and the increase in our knowledge of lightning's behaviour that has brought it about. He stated that the impulse characteristics of most line and station insulators had been established on a quantitative basis, suitable for application to the station design. The extensive experience gained in impulse testing several million kVA of transformers and other station apparatus had contributed in a large measure to evaluate the basic requirements and also the essential details which must be fulfilled to secure co-ordination and protection. The lightning arrester had been the object of additional experimental verification and of further improvement in its twofold function to provide protection of the station apparatus against damage and protection of the service against breakdown. The methods and findings acquired from experience with transmission lines had been extended to shield and effectively to protect the stations against direct strokes of lightning.

Air and Water

ADMIRALTY CIVIL ENGINEER-IN-CHIEF.—The Secretary of the Admiralty announces that Mr. F. A. Whitaker, M.Eng., M. Inst. C.E., Deputy Civil Engineer-in-Chief, has been appointed to succeed Sir Athol L. Anderson, M. Inst. C.E., as Civil Engineer-in-Chief, to date January 18th, 1940.

H.M.S. "DIDO."—The launch took place on Tuesday, July 18th, of H.M. cruiser "Dido," which is under construction for the British Admiralty by Cammell Laird and Co., Ltd. The vessel has a standard displacement of 5450 tons and carries 5·25in. guns. She was laid down in October, 1937.

FIRE-FIGHTING EQUIPMENT FLOWN TO FIRE.—Three aircraft left Croydon recently with asbestos fire-fighting equipment to be used to help to put out a serious fire at an oil well in Saudi Arabia. They are flying to Bahrein, whence the equipment will be taken across the Strait in launches to Al Khobar on the Arabian mainland, near the burning well.

SHIPBUILDING INDUSTRY CONCILIATION.—Mr. James Gordon McIntyre has accepted the invitation of the Shipbuilding Employers' Federation and the Confederation of Shipbuilding and Engineering Unions to act as independent chairman of the conciliation machinery to settle disputes in the shipbuilding and ship-repairing industry. He succeeds Lord Patrick, the new judge in the Court of Session.

BRITISH ATLANTIC MAIL SERVICE.—The first British air mail service across the North Atlantic will be started on August 5th, by the flying boat "Cabot" leaving Southampton for Botwood. The service will be weekly in each direction between Southampton, Botwood, Montreal, and New York, carried out by the two aircraft "Cabot" and "Caribou," each carrying 1000 lb. of mail, estimated to consist of about 25,000 letters.

BRITISH SHIPYARDS IN CANADA.—According to a note in the *Journal of Commerce*, British shipbuilding companies may soon establish yards in Canada. It is reported that Vice-Admiral Sir Reginald Skelton, a director of John I. Thornycroft and Co., Ltd., who is at present in Canada, has been investigating the possibilities of establishing yards in the Dominion. Sites have been considered, and it is very probable that those chosen will be on the St. Lawrence River.

LONG SERVICE OF "HERACLES."—The Imperial Airways aircraft "Heracles," has passed her eighth annual examination for the official certificate of airworthiness. She was first commissioned in 1931, and her log book shows that she has flown more than 13,000 hours, flying a total distance of about 1,300,000 miles, and carrying more than 100,000 passengers. It was found at the examination that there were no major parts needing renewal.

"GRANTULLY CASTLE" TO BE SCRAPPED.—The Union-Castle liner "Grantully Castle," built in 1910 by Barclay, Curle and Co., Ltd., is to be broken up. We are informed that P. and W. MacLellan, Ltd., of Bo'ness and Glasgow, have purchased the vessel, and that she is expected at the firm's Firth of Forth yard at the end of the month. The "Grantully Castle," which was in service until recently on the South and East African routes, was a hospital ship during the war, together with several other Union-Castle liners. She has a gross capacity of 7592 tons.

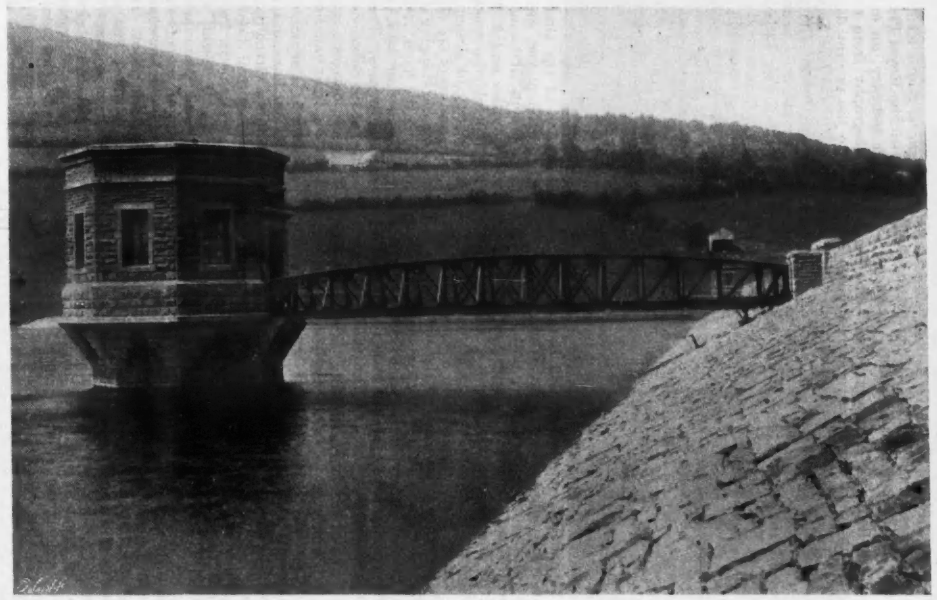
AMERICAN BOMBER FLIES THE ATLANTIC.—The Consolidated 15-ton flying boat, built for the R.A.F. in San Diego, California, left Botwood on July 13th and flew non-stop to Felixstowe, a distance of 2450 miles, arriving at 6 a.m. on July 14th. The boat was previously flown non-stop from San Diego to Botwood, a distance of 3300 miles. It is the first military aircraft to be delivered by air across the Atlantic. The machine is a twin-engined flying boat, with retractable wing tip floats, and is of a type used as a long-range bomber by the United States Navy, having, it is reported, a range of 4200 miles with a military load.

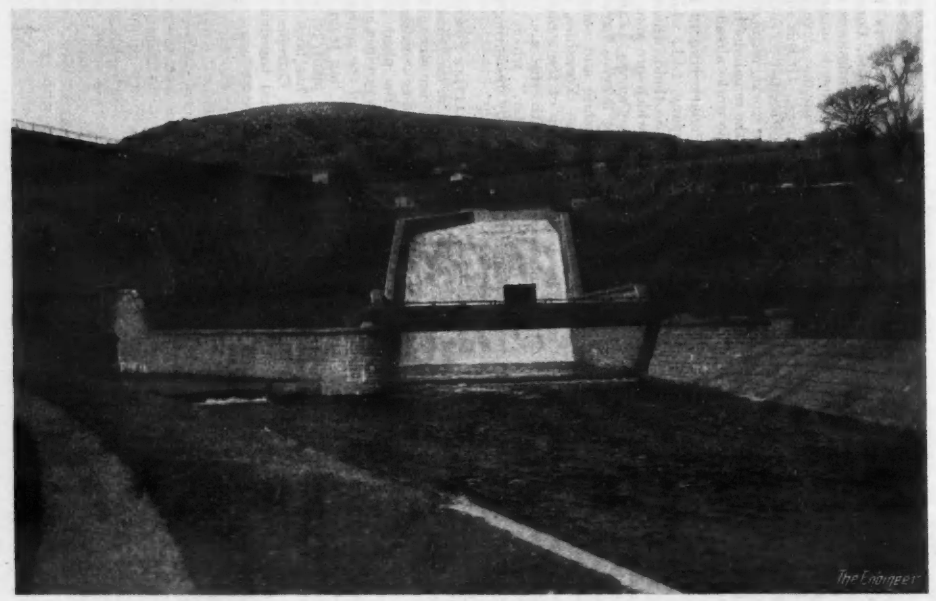
BRITISH ATLANTIC AIR SERVICE.—The "Caribou," the first of the Imperial Airways transatlantic flying-boats has left Rochester for the Air Ministry's Marine Aircraft Experimental Establishment at Felixstowe, where it will undergo official tests for a certificate of airworthiness. Tests have already successfully been made in mid-air refuelling. The flying-boats "Caribou" and "Cabot" are expected to begin the British transatlantic service in August. Later, the bigger flying-boat "Golden Hind," which has yet to make its first flight from Rochester, will take part in the service. Imperial Airways state that difficulties encountered in the first experiments with flight refuelling have been overcome, and that 1000 gallons of petrol can now be passed from the tanker to the flying-boat at an altitude of 1000ft. New tanks have been designed and the fuel can be distributed evenly amongst the three tanks of the flying-boat. A new method has also been devised for establishing the first contact between the tanker and the flying-boat.

INVESTIGATION OF THE "CALPURNIA" FLYING ACCIDENT.—The Air Ministry announces that the accident in Iraq on November 27th, 1938, to the Empire flying boat "G-AETW," "Calpurnia," belonging to Imperial Airways, Ltd., in which four employees of the company lost their lives and two were injured, one seriously, has now been investigated by an Air Ministry Inspector of Accidents. The Inspector came to the conclusions that towards the end of the flight the pilot, uncertain of his exact location and unable on account of strong atmospherics to receive the wireless bearings sent to him, was flying very low in darkness and adverse weather conditions in an endeavour to fix his position by ground observation. Further, that during this period the pilot failed fully to realise how dangerously low he was and allowed the aircraft to strike the water with the engines running under power. The Chief Inspector of Accidents, while agreeing with the Inspector's conclusions, drew attention to the desirability of improvements in the civil wireless organisation on this particular sector of the Empire air route as it existed at the time of the accident. Proposals for a modification of the radio control organisation in the Iraq sector are now being considered by the Iraq Government.

CONSTRUCTION OF TALYBONT RESERVOIR, BRECONSHIRE

(*For description see page 64*)





PROGRESS OF CONSTRUCTION OF CORE WALL—1934 AND 1935

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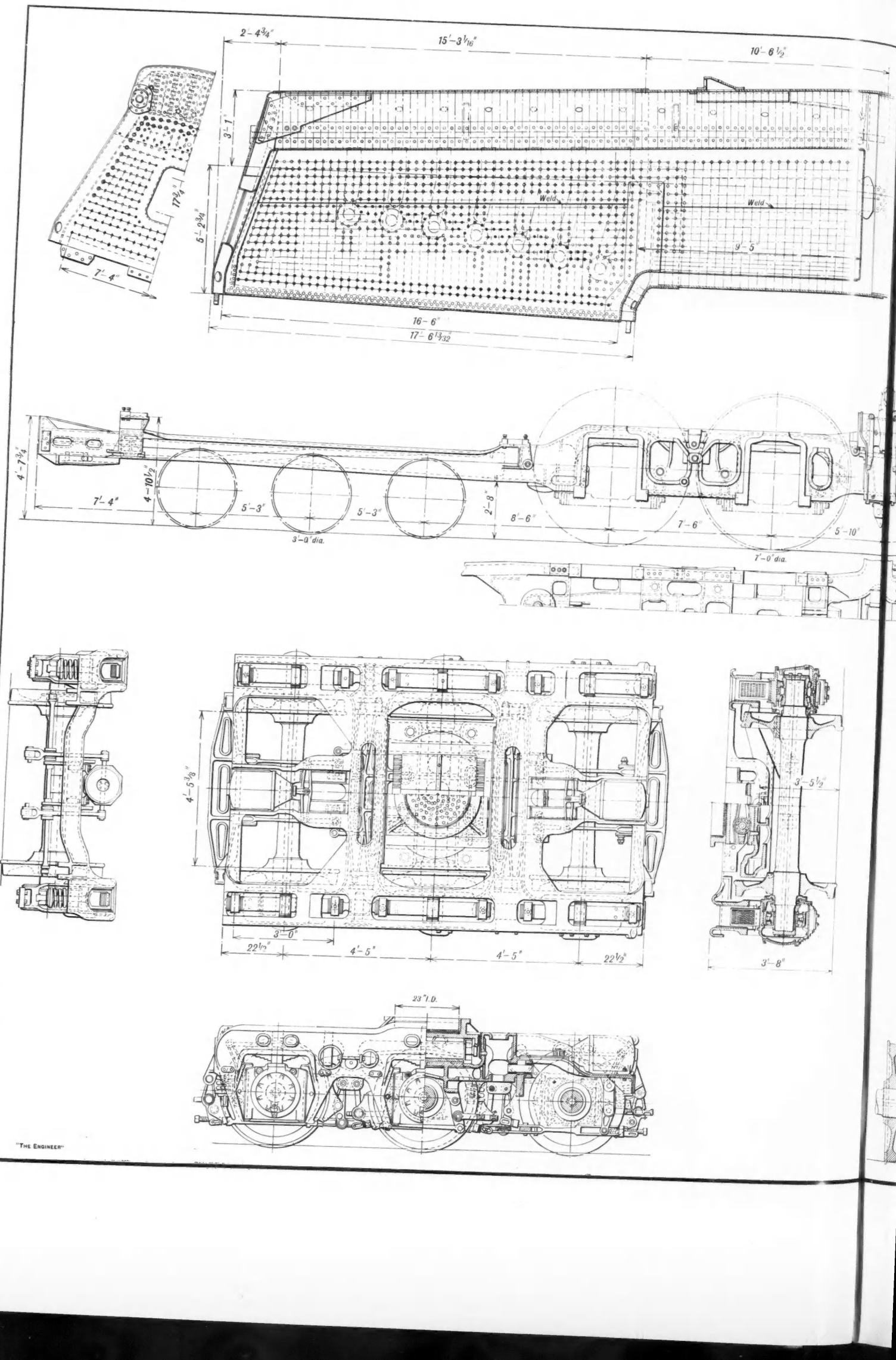
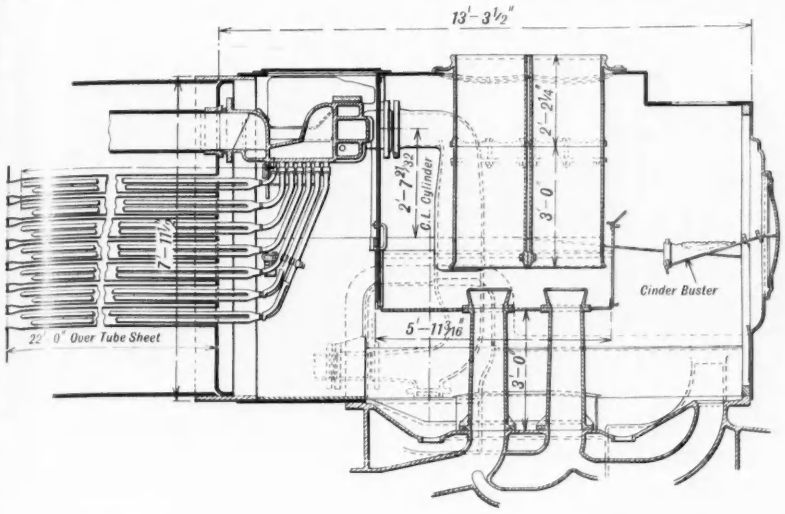
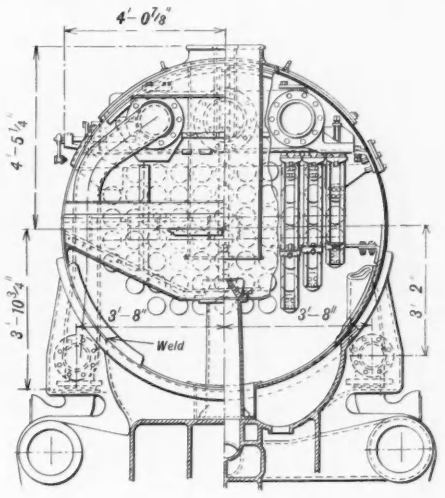
SPILLWAY APRON AND STILLING POOL

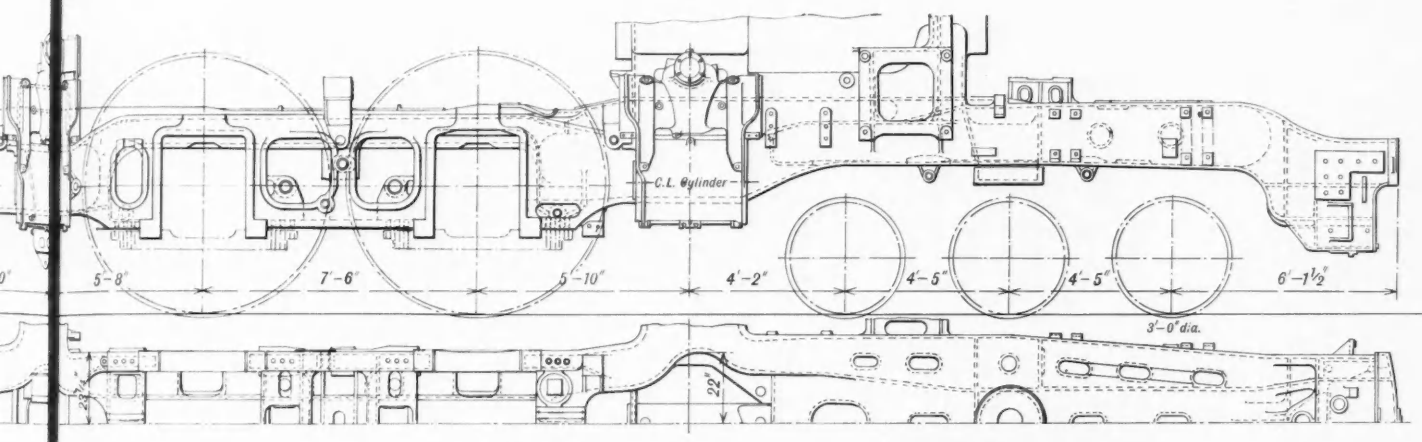
PENNSYLVANIA RAILROAD—6-4-4-6 H

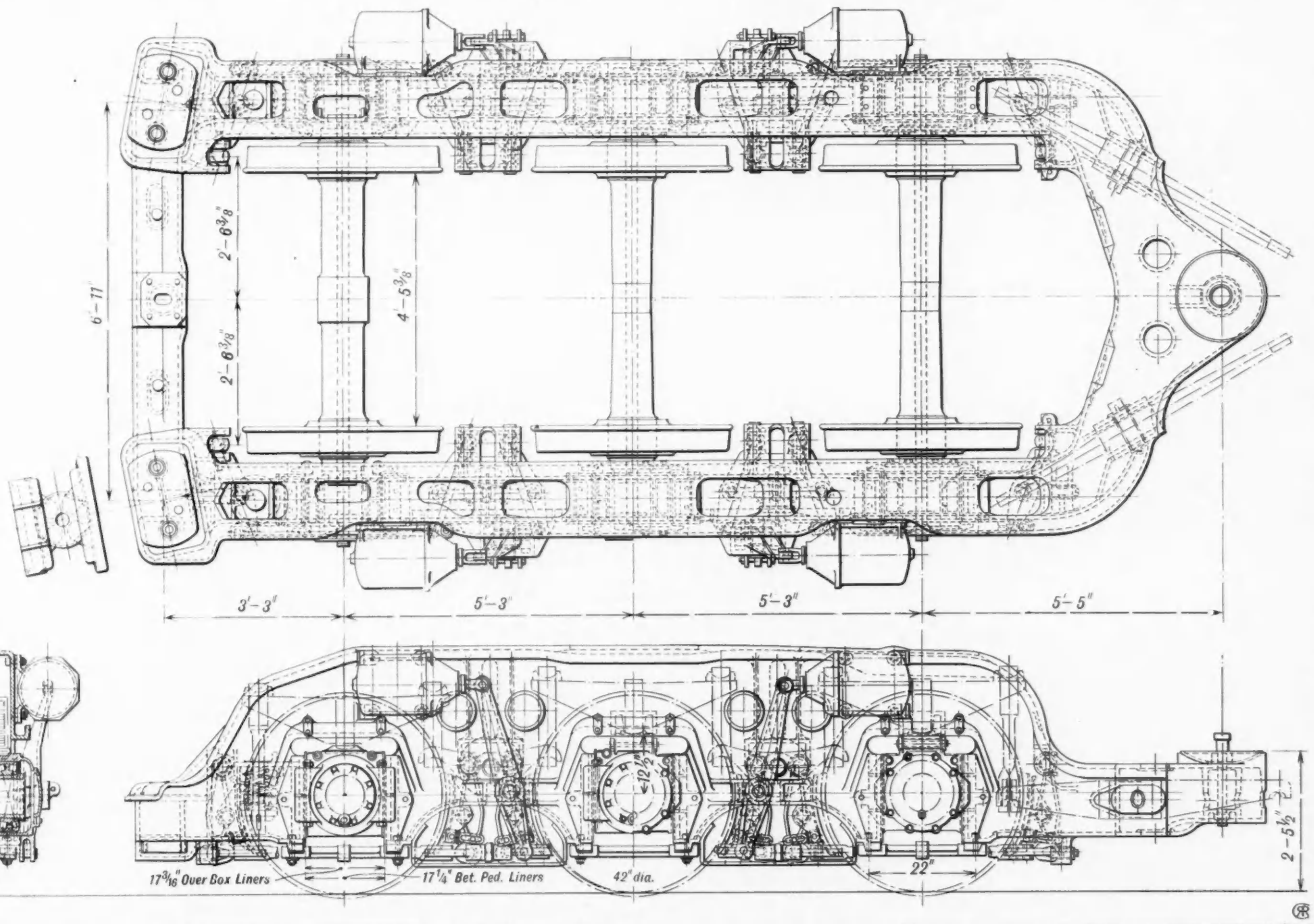


6 HIGH-SPEED PASSENGER LOCOMOTIVE









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FIRE IN THE AIR

FEW mishaps are more feared than fire in the air, and it is fortunate that they occur but rarely. Fires after crash, unhappily more common, are due to quite other causes than those that lead to them whilst in flight. Perhaps the most striking recent instances of fire in the air are those that have occurred recently to moored balloons. Here we have hydrogen-filled envelopes attached to the earth by some thousands of feet of steel cable. It is not practicable to insulate the operative winch and its lorry from the earth, for that would merely make them unsafe to handle by the ground personnel; since the winch would in such circumstances take up the electrical potential prevailing in the atmosphere at the height level at which the balloon was flying. The earth itself is known to carry a negative charge, whilst the electrical potential of the air changes as one rises at a rate, which though it varies much with geographical position and with the state of the weather, begins commonly at some 150 volts per metre. This rate of change usually decreases rapidly with altitude until at 10,000ft. it is only a fraction of the sea level value; but it still exists, and at such an elevation there may be an electric potential differing from that at the ground by many tens of thousands of volts—amply sufficient to give rise to brush discharges and actual sparking. Hence in the case of a moored balloon with the earth end of the cable at ground potential, the end attached to the balloon, and the balloon itself in so far as it is conducting, will be at a very different potential indeed from that of the atmosphere surrounding it.

It is this circumstance which, given the right atmospheric conditions, has without doubt been the cause of the fires which have occurred. When electrical storms arise in the neighbourhood of the balloons, the steel cables naturally afford attractively easy paths to the earth. The aeroplane, however, even when used to trail a long wire with a gunnery target at the far end, is little affected by these potentials, and in the special case cited the wire is vastly nearer the horizontal than the vertical, and the difference of electric potential at the two ends is correspondingly less. Fires in the air, occurring in aeroplanes, have sometimes been due to the jettisoning of fuel. It might have been expected that the very high air speed at which such craft fly would ensure that the liquid and its vapour would be carried away so rapidly that no juxtaposition of vapour and electrical apparatus could possibly occur. But this is not the case. One of the remarkable facts about the air flow around and in an aeroplane is that reversed flow is not uncommon. Air has an almost uncanny way in some conditions of flowing backwards. This is no doubt due to the varying air pressures at the surfaces along which the air flows. Inside the craft the air will tend to flow from a leak where the outside pressure is high to some other where it chances to be low, and it not infrequently happens that some of the outside air gets drawn in, and when this air is charged with petrol vapour there must be occasions when the richness of the mixture will be within the explosive limits, and if then, by a second chance—admittedly a double event and therefore rare—this particular mixture happens to pass into some electrical gear, an explosion may result, and the rest of the petrol catch fire. It will easily be seen that such events must be exceedingly uncommon, but when they do occur they often seem almost mysterious in origin. The truth is that most often any mixture drawn in has a non-explosive strength or meets no electrical apparatus in its path. Then for one reason or both nothing happens, and no one is even conscious that any particular risk had been encountered—such lucky escapes therefore go unrecorded, and are indeed unrecordable. Hence the apparent mysteriousness on those occasions when fires do occur. The remedy is to provide that the jettison arrangements shall be such as to ensure that none of the fuel comes near any part of the surface of the aeroplane, and, in particular, not near any part of the fuselage. With these precautions safety can be ensured, but they require a thorough knowledge of the nature of the air flow, which, of course, varies with every type of aeroplane. It may be asked whether there is no other way in which the undesired spark may be caused. It is known, for instance, that when falling drops of liquid break up on reaching a stream of air, they become electrically charged. Thus falling rain is believed to cause the growth of the high electrical potentials which occur in an electrical storm. It is difficult to see, however, how in the short space of time occupied by jettisoning any very considerable potentials would have time to build up. Dr. Seewald, of the D.V.L., Berlin, in a recent lecture to the Royal Aeronautical Society, stated that tests with models showed no electric charge sufficient to cause ignition. But it is well known that in filling a tank on the ground it is possible, if the liquid splashes, to build up dangerous potentials—fires have even been known to arise in such conditions. Fortunately, however, the precautions necessary to guard against such occurrences are known and taken.

The most direct way to avoid petrol fires in the air is to use a safer fuel. The compression ignition engine uses fuel which is safe in this regard, and it is a pity that such engines appear never to be able to compete with the petrol engine in either lightness or reliability. As a consequence, the latter are invariably demanded for military craft, where high performance is essential, whilst in civil craft the marginal difference is still great enough to cause the petrol engine to be preferred. This state of affairs is doubtless due in part to the much larger sums of money and time devoted to the improvement of the petrol engine, since that offers the greatest chance of rapid improvement in aircraft performance. Some day, however, other considerations will prevail, and one cannot doubt that ultimately a safer fuel than petrol will be in common use.

Armaments and Industry in France

How to increase the industrial production and provide revenue out of foreign trade that will contribute to the cost of intensive armaments is a problem that has long occupied the attention of the French Government. As France depends upon supplies of foreign materials and products, she has always had an adverse balance of trade, which was of little moment when the deficit could be covered by invisible exports. But a situation that had become increasingly serious over a long period culminated in a dangerous crisis when the events of three years ago brought a collapse of the country's economic structure. On the present Government being formed to avert a threatened disaster, it was confronted with the task of increasing the national revenue at a time when it was necessary to make a huge expenditure on armaments. The balancing of foreign trade, which has always been regarded as a safe objective, despite the logic of economists, now became one of the essential features of the new policy, for revenue from shipping and other services abroad was disappearing and foreign investments could not be relied upon sufficiently to reduce the unfavourable trade balance. Consequently, any adverse balance is regarded as the equivalent of so much gold leaving the country. Unless the national revenue keeps pace with the increasingly heavy burden of armaments there must come a time of economic exhaustion. It is sought to avoid this disagreeable prospect by a reorganisation of industry which has already been carried out on a considerable scale. A first obvious result of the Government's economic policy is a reduction of nearly 30 per cent. in the foreign trade deficit for the first half of the present year, as compared with the first six months of 1938. It should be borne in mind that in the latter period the average exchange rate against sterling was 18 per cent. less than at the end of June last year, since which time the rate has remained stable. Import values of materials and produce increased with a lessened tonnage, and the cost of imported materials was reflected on exports, particularly of manufactured goods, which underwent a fractional decline in tonnage and advanced by nearly 25 per cent. in value. The higher prices paid for imported materials are not alone responsible for the appreciation of export values. The cost of production always tends to rise, and the failure to control prices under this pressure, without depriving manufacturers of reasonable profits, has induced the Government to prepare further measures in favour of foreign exchanges which are expected to be promulgated shortly by decree.

If manufacturing industries are to do more to help national revenue by building up a larger export trade while most of them are engaged wholly or partly on armament work, it follows that they must depend on the State for means to carry on under conditions that are controlled by the State. Manufacturers were left to their own devices when the more important of them changed their production methods and put down modern plant and machinery to meet new conditions imposed by the forty hours' week. So far as the general body of manufacturers were concerned, nothing could be done at a time of severe financial depression when confidence was entirely lacking. The present French Government changed all that by reverting to a normal economic policy. It restored financial confidence and reorganised industry with a view to increasing production to its maximum and developing exports. All manufacturers, big and small, were encouraged and helped to bring their equipments thoroughly up to date. Now that the hours of labour are adapted to the necessities of production, industry is able to supply, not only heavy demands for armaments, but also everything in the nature of normal French products that can be exported under present con-

ditions of international trade. The whole problem of foreign trade is in the hands of the National Economic Council which advises the Government on matters affecting the national economy. All classes interested in foreign trade are represented on the Council, including four groups in the employers' section, three of which are associated with the General Confederation of French Employers. No action is taken by the Government on any matter until it has been fully examined and reported on by the National Economic Council. Decisions are not easily reached when compromises have to satisfy conflicting interests. The main conflict is between the national staple industry of agriculture and manufacturing industries, whose interests do not always coincide. Nevertheless, armaments have now placed engineering on a higher plane, and more importance is attached to production for export than ever before. While manufacturers are offered some alleviation from industrial taxation on goods for export, there is no direct subsidy, nor is there likely to be any, and in view of high production costs, it is urged that makers should concentrate on quality goods for export which would be less affected by international competition. Among the Government's plans that are expected to be embodied in decrees is one for an adjustment of import duties in a manner to check a continuous advance in living costs upon which workers' wages are based.

In private industry manufacturers are handicapped by the conditions under which the supply of skilled workers, controlled by the Minister of Labour, necessarily favours armament production. While employers not so favoured have to do the best they can with the labour available, and are training men with an assurance given by the State that they will have the right to retain such men, they are unable to pay the high wages prevalent in armament works. For this reason, the Government must take more effective measures to prevent living costs from inflating, and, if possible, to lower them. It is now seen that if foreign markets are to be retained, expedients that have hampered trade must give way to a more liberal view of national economy, and this change is already observable in successful negotiations with a number of countries that give promise of good results. Unfortunately, the same thing cannot be said of exchanges with totalitarian States, which have usually proved disappointing. The arrangement, for example, with Germany for exchanging iron ore for blast-furnace coke failed because the supply of coke fell short of the stipulated quantity, and caused trouble to French blast-furnace owners. Such arrangements are not always reliable. How difficult is the situation was made clear at the meeting of the International Chamber of Commerce at Copenhagen. It presented a plan for putting international trade on a normal basis in co-operation with Germany and Italy, but a statement by Dr. Pirelli, the Italian Minister and industrial authority in his country, showed the futility of any such plan. Italy will have nothing to do with a return to gold as a medium of exchange. The "golden age," he said, is past, and must be replaced by an new system involving an equal distribution of materials. All countries must have their due share, but how this can be accomplished without a medium of exchange was not explained.

"Pacific" Locomotives in India

IN our last two numbers we have discussed in leading articles the Report on "Pacific" engines recently presented by a Committee to the Government of India. In our issue of July 7th, we gave in full the Committee's conclusions, and to-day we reprint the first part of Chapter III. The Report is now available in this country and can be purchased from the India Office, Whitehall, for 6s. 9d. The following summary of the contents, chapter by chapter, may be of service to general readers, but we have no doubt that all locomotive experts, either as operators or makers, will desire to study the original itself.

Chapter I may be dealt with very briefly. It records the appointment of the Committee, its constitution, and the terms of reference, which were "to consider the design and operation of three classes of engines, viz., 'X A,' 'X B,' and 'X C' types, and to advise on" the suitability of the design and other matters. There follows a section describing the activities and tour of the Committee and the usual acknowledgments. Then comes a presentation of the "General Aspect of the Problem under the Following Headings:—Relationship Between Rolling Stock and Track; Permanent Way; Locomotive Design; Examples of Unsatisfactory Design; Research; Track Maintenance; The Economic Aspect; Springing and Control of the Locomotive; and Necessity for Compromise." We give this list because it indicates clearly the scope of the work undertaken by the Committee.

In Chapter II we have a history of "Pacific" locomotives in India. In 1920–21 a Committee—familiarly known as the Acworth Committee—reported on the condition of Indian railway systems which had been badly affected by events following the Great War. The Report was very severe indeed. The expenditure of a great deal of money was recommended, and in March, 1922, the Legislative Assembly advised the Governor-General in Council to spend Crores 30 on locomotives alone. We need not follow the financial discussions which followed, and the proposals of the Inchcape Committee of 1923 on retrenchment. One of the costs that affect the subject before us was the expenditure on locomotive coal. Although between 1913–14 and 1922–23 engine mileage had only risen by 12 per cent. on the broad gauge, the fuel bill had more than doubled. The question of burning a cheaper and more generally accessible fuel therefore arose, and the decision to use wide fire-boxes followed naturally. In practice, that meant the "Pacific" type. Experiments began in 1919 with meter-gauge engines, and two years later two 4–6–2 and two 2–8–2 locomotives with wide boxes were ordered for extensive trial. Some American engines were also tested. On the whole the tests were not unsatisfactory, but some modifications were called for.

A great deal of this chapter is devoted to standardisation, and the activities of the Locomotive Standards Committee which formulated the designs for the "Pacific" engines:—"X A" Branch, with 17½in. by 26in. cylinders and 61½in. wheels; "X B" Light, with 21½in. by 28in. cylinders and 74in. wheels; and "X C" Heavy with 23in. by 28in. cylinders and 74in. wheels. A summary of the performance of the "X" class is given year by year from 1928 onwards. Of the "X As" the G.I.P.R. had forty-nine, and six derailments occurred between April, 1930, and June, 1931; the N.W.R. ran fifty-eight similar standard engines, but had no trouble with them. The "X Bs" appeared to be satisfactory till the derailment at Bihta; and the "X Cs"—number not stated—have covered 21 million miles without accident.

We need not attempt to summarise Chapter III of the Report, for, as already stated, we are reprinting it. It is a treatise on the locomotive as a vehicle, and will be examined with the closest interest by locomotive men.

Chapter IV is devoted to "Permanent Way: Maintenance: Speed," and special attention is paid to the lateral resistance of the track and "to factors which, by permitting vertical deflections, may initiate oscillation and hunting of engines sensitive to track conditions." With regard to sleepers, the Committee, whilst recognising that pot and plate sleepers have been in extensive use for many years, thinks that consideration should be given to "the extended use of rigid type sleepers, where formation is unstable," and adds that "the impression should not be allowed to gain ground that the heavier the rail, the less the need for increasing the number of sleepers."

On the question of Maintenance, it is obvious that the Committee was not entirely satisfied—"there has evidently been a general falling off," it says, "in the number of miles of track and of track components renewed, and of betterments effected," and it recommends that "the whole question of track maintenance should now be subjected to a comprehensive review, with special reference to the determination of maximum permissible speeds in monsoon and dry weather periods respectively."

Discussing Speed, the Committee expresses the opinion that India is a 56–65 mile per hour country, and that it is economically impracticable to attempt maxima of 65–75 m.p.h. Even the lower speeds may be too high during the rains in certain parts of the country.

The Committee covered over 3000 miles on the footplates of twenty-nine engines of different types, whilst the condition of the track was being observed by a Hallade recorder fixed in one vehicle of the train which constituted the party's headquarters. In Chapter V we have comments on the footplate experiences, and on the characteristics of the locomotives and tracks. To attempt to give details is out of the question, and we must ask our readers to be content with extracts from summaries or to consult the Report itself, where everything of any consequence is set down. "The experiences and records," says the Committee, "for 'X' class 'Pacifics' in original condition illustrate how sensitive these engines are to track irregularities; they also show why reports of different administrations upon performance were often contradictory and of a baffling nature, if conditions of engine and track were not given full recognition." When the engines were fitted with Ferodo liners on the bogie, flat slides with Ferodo on the hind truck, and German buffing gear, "they were free from appreciable tendency to nose or hunt," provided they were in good condition.

One of the engines was a non-standard built by Baldwins, a four-cylinder compound. Its condition at the time of the test was not first-rate, but although it rode roughly "there was no tendency for oscillation to build up." The Committee also studied two 4–6–0 engines, and, finally, an "X C" specially modified to meet its requirements. "The bogie was of laminated spring type with roller bearings, and had new springs, giving 5 tons initial and 8 tons final control; it also had side bearers, without any friction material. The hind truck had flat slides and Ferodo." It had done 800 miles since repairs and these alterations. The running was particularly smooth and steady at speeds up to 60 m.p.h. over a road with considerable curvature. The Committee recommends that "experiments should be made with this engine to ascertain the extent of flange forces exerted on straight and curves at varying speeds."

We come now to Chapter VI, which is headed Engine Maintenance. It is based in part on interviews and in part on observations the Committee itself made during visits to eight workshops and seven running sheds. The fact is stressed that the better the condition of an engine, "the less is the incidence of oscillation and of the trouble which results therefrom, in the form of distortion of track, cracked frames, &c.," but the interesting fact that the "X B" engine involved in the Bihta derailment had just been through the shops is noted. "Therefore," concludes the Committee, "it seems doubtful whether engine maintenance, as such, can have had a material bearing upon the circumstances, unless, for instance, the bogie mechanism was defective in this respect."

On the whole, the Committee was satisfied with the standard of maintenance of engines, and it was clearly convinced that design and not lack of attention to upkeep was the source of troubles. After discussing the forms of wear and play which affect hunting, and other forms of side play in some detail, the Report touches upon Organisation as it affects maintenance. It is noted that one of the principal difficulties in a country the size of India is that of promptly collating information, and that is thought to be one of the reasons for not getting to the bottom of the trouble with "X" class engines earlier. Hence, the Committee recommends the appointment of "young practical officers as Mechanical Inspectors, directly responsible to the Chief Mechanical Engineers. They should be free of routine work, and their duties should be to visit sheds at any or all hours, to advise on the best methods of maintenance of locomotives, and to bring back direct to headquarters particulars of troubles experienced, either on the footplate or in running sheds."

In Chapter VII we have a useful survey of Research and Development in various parts of the world. There is so much in this review of practical interest to railway and general engineers that we propose to print a good deal of it as occasion offers. We need, therefore, only say at the present moment that the Committee, whilst recognising what had

already been done, recommends the extension of railway research in India.

In the next three chapters, Nos. VIII, IX, and X, the Report gives the specific replies of the Committee to the questions propounded in the terms of reference. The conclusions that followed form Chapter XI, which was reprinted in our issue of July 7th. From the three chapters named above we pick out one or two comments of outstanding interest :—

It had been suggested that on the Indian railways with their 5ft. 6in. gauge 4–6–0s would have been practicable, but in the view of the Committee the choice of the "Pacific" type was logical, and there is nothing to be said against it. But the Committee does not think the particular design was suitable for high speeds, and in its opinion "the selected types of bogie, hind truck, and coupling between engine and tender, were unsuitable, and the amount of side control provided was inadequate." From the first, the engines exhibited undue oscillation and caused track distortion, and between March, 1929, and March, 1938, no less than twenty-eight major modifications were tried. Great improvement was effected, but the Committee says that, even with some further modifications the engine "would not appear to be suitable for unrestricted running in the type of work for which they were designed and over the tracks of the country in which they must travel." It recommends therefore that the maximum speed of 45 m.p.h. should not be exceeded, even with engines that have been modified.

On the matter of Permanent Way it is recommended that closer attention should be paid to the appropriate spacing of sleepers, and "the necessity for research into the bearing capacity of different kinds of soil encountered in India under varying conditions of moisture" is stressed.

The Committee advances in considerable detail its own recommendations for the improvement of "X" class "Pacifics," and gives advice as to the features to be observed if new engines should be ordered. In particular, it does not find the Cartazzi slides suitable for Indian conditions, and it recommends spring control for the hind truck as well as the bogie.

It has been impossible in a review of a reasonable length to give more than the bare bones of a very long report. Every one of the conclusions recorded is supported by careful arguments and the records of observations. We have perhaps given more weight than is due to what may be described as the technical aspects of the Report, and it is necessary to say that a great deal of it is, in fact, devoted to administrative matters and financial questions. We do not underrate the vast importance of these matters, and the Report leaves us with the feeling that the question of finance is still one of vital importance on Indian railways. Indeed, it might almost be said that until it is settled the hands of engineers will be tied and it will be impossible to carry out as completely as might be wished the recommendations of this Committee of Experts.

Obituary

W. R. WOOD

EVERYONE who knew him will hear with sorrow of the death of Mr. W. R. Wood in New York on July 14th. Although he retained his American citizenship, he lived so long in this country, was so attached to it, and so critical of certain aspects of American life, that many people must have regarded him as an Englishman. With his unquestionable skill as a combustion engineer was coupled a lively wit and a charm of conversation which made him a very desirable companion.

He came to this country in 1899, leaving the American Stoker Company to take an active part in the formation of the Underfeed Stoker Company, Ltd., a company in which he successively held the position of general manager, managing director, and chairman. The association of that company with a group of companies controlled by the International Combustion Corporation of America, and the formation of International Combustion, Ltd., were effected by him and are sufficiently recent to be well known.

He will always be remembered as a pioneer in the development of the forced draught retort type stokers. The Class B Underfeed stoker was designed by him shortly after his arrival in this country, and with the retort type stokers for water-tube boilers, formed for some years the main part of the company's business. In both these stokers the principle of a pressure supply of overhead air to secure smokeless combustion was employed. Later he invented, designed, and constructed a forced draught travelling grate stoker. Despite the opposition it encountered, this stoker may be regarded as the forerunner of a type in general use to-day. Another important development for which he was responsible was the design of a plate type air heater, and his advocacy of air heating did much to secure the adoption of air heaters as standard practice in the power stations of this and other countries.

W. R. Wood took an active part in securing the interest of power station engineers of this country in the use of powdered fuel for power generation and this led him to the realisation that this system would justify an entirely different conception of the proper relation between the combustion chamber and the boiler. The Wood steam generator, designed and patented by him, was the result of this conviction, and the essential features of this boiler are to be seen in many of the designs for modern plants.

His attractive personality, made up of genius, an aptitude for concentrated effort, and a keen sense of humour, secured for him a great many friends, both in technical and social circles. His outlook on life was broad enough to enable him to enjoy its pleasures as well as its work. He was a keen lover of the river and sea; boating, yachting, and golf afforded him joys of which he had a real appreciation. His friends will remember him for these things, but technologists of the future will have to recognise that he exerted a great influence in the field of combustion engineering all over the world.

Literature

SHORT NOTICES

The Commissioning of Electrical Plant and Associated Problems. By R. C. H. Richardson. London: Chapman and Hall. 1938. Price 21s.—Forming Volume V of the series of monographs under the editorship of Mr. H. P. Young, this book on "The Commissioning of Electrical Plant and Associated Problems" should appeal to many practical men. The object of the volume is to present general and precise information which has been found useful when setting to work A.C. and D.C. generating plant, transforming, motive, and converting plant. The behaviour of machines and apparatus when put into use for the first time cannot completely be forecast, and although careful preliminary checking and preparation of plant will usually result in trouble-free performance, the acquirement of initial operating characteristics will, the author claims, provide in many respects the most important guide to successful performance and life. Possible troubles may thereby be anticipated and the appropriate remedies applied. Although no specific defects may be encountered during the commissioning period, the information afforded by the preliminary tests may point to the necessity for some special investigations and adjustments in order that the best results may be obtained. Among the more important sections of the book are those on the preparation of alternators for commercial service, the parallel operation of alternators, and alternator troubles. Other sections of the book devoted to A.C. work deal with the commissioning and parallel operation of transformers and transformer troubles. In the D.C. section of the volume the machines covered are generators, motors, and rotary converters. A chapter on mercury arc rectifiers describes the principle on which this apparatus works and discusses various troubles that are liable to arise. Lastly, a chapter is devoted to some technical methods used in electrical engineering work.

Electrical Engineering Practice. By J. W. Meares and R. E. Neale. London: Chapman and Hall. 1938. Price 25s.—While the general plan of the fifth edition of Volume I of this work remains unaltered so far as the general plan is concerned, the book has been thoroughly revised, taking into account advances in equipment and practice as well as the radical alterations in the supply situation resulting from the operations of the Central Electricity Board in Great Britain and corresponding developments in other countries. As in previous editions, it has been the authors' aim to present information and explanations likely to be of maximum utility to engineers in practice and to students. Numerical examples based on practice are given freely, and while care has been taken to bring the book into line with the latest requirements, information on older methods and equipment is retained where it is likely to be useful in relation to plant still good for years of service. No fewer than 200 additional pages have been added to the new volume and a comprehensive index to all three volumes of the work is now provided. Apart from additional matter in every chapter, the whole of the material, including the technical and statistical tables, has been thoroughly revised. New illustrations have also been added and the bibliographies appended to each chapter have also been brought up to date.

How to Make Working Diagram Models. By H. R. Langman. London: The Technical Press, Ltd. 1939. Price 3s. 6d.—Working models which may be constructed from odd pieces of cardboard or plywood to elucidate electrical principles and phenomena and to explain the working of some electrical machines are described in this book. The main object of these models, it seems, is to help teachers who give instruction in technical schools, as in some instances many blackboard sketches would be necessary to portray what the models convey in a few moments. Although there is some diversity of opinion regarding the value of models in demonstrating electrical principles, many highly ingenious models for the purpose have been devised, and teachers interested in the matter will no doubt find something that appeals to them in this small volume.

The Principles of Electric Power Transmission. By H. Waddicor. London: Chapman and Hall. 1939. Price 21s.—The principal alteration to the fourth edition of this book is in connection with underground cables. Chapter X, dealing with the thermal characteristics, has been considerably revised and incorporates new data and methods of calculation for the determination of current rating based substantially on the work carried out during the last five years by the British Electrical and Allied Industries Research Association. The book meets the needs of students pursuing a course of study in electrical power transmission at universities and technical colleges. The practical side of the subject has, however, been kept in view and the subject matter is not without interest to designers and engineers responsible for the operation of power transmission systems.

Sixty Years Ago

THE CAUSE OF BOILER EXPLOSIONS

FOR many years there was much debate concerning the cause or causes which led to the explosion of boilers. It was almost universally felt that in a number of cases there was an element of mystery, so much so that every explosion which could not be clearly traced to shortness of water or extensive corrosion was regarded as mysterious and remarkable. Numberless theories were advanced, some of them almost as mysterious as the phenomenon which they were designed to explain. A well-favoured theory was that of Boutigny d'Evreux. This theory was based on the physical fact that when water is dropped on a hot plate it assumes the spheroidal condition, runs about in drops, and evaporates slowly. It was assumed that in certain conditions the water in a boiler might be in the spheroidal condition, and that when the plates cooled a little the drops would flash suddenly into steam, so much of which would be produced in a few seconds that the boiler would burst. Then there was the electrical theory. Writing on the subject in a leading article in our issue of July 18th, 1879, we stated that we had never understood what the electrical theory meant, nor had we ever met anyone who did. We recorded, however, that, guided by it, one gentleman had promised to prevent all boiler explosions by encasing boilers in thin sheet copper, while another proposed to attach conducting wires to the boiler to put it into connection with the earth. Yet another theory assumed that boiler explosions could result from the decomposition of water into hydrogen and oxygen and their reunion with terrible violence. The inspecting engineers of the boiler insurance companies succeeded at last in putting the subject on a proper footing. They showed that boilers burst simply because they were too weak to withstand the internal pressure and that in the vast majority of cases furrowing, grooving, and corrosion were the prime causes of boiler explosions. In the leading article to which we have referred, we questioned whether the companies' inspectors had not gone a little too far and by assigning all explosions to one cause they were not stopping inquiry into certain secrets of Nature concerning which we knew less than was desirable. Two recent mishaps provided us with illustrations for our argument. At Coltness six boilers out of a group of ten had exploded simultaneously. At Kersley one boiler had burst leaving the adjoining seven quite undamaged. This marked difference of behaviour seemed to suggest that some unknown cause had been present in one case and not in the other. What was it? We left our readers with the suggestion that the behaviour of water heated under oil was very curious and that the boiling point of water could be altered by various conditions other than pressure.

A Sheet Metal Roller Levelling Machine

THE high standard of accuracy and rate of production now required in the making of pressed metal products necessitates the use of dead flat sheets which have been relieved of any internal stresses set up in their manufacture. It is now common practice to pass all sheets through roller levelling machines before any stamping operations are carried out. These machines serve to correct any variation in thickness and, by bending the sheets above the elastic limit, as they pass through the rolls, relieve internal stresses likely to cause deformation in the finished product.

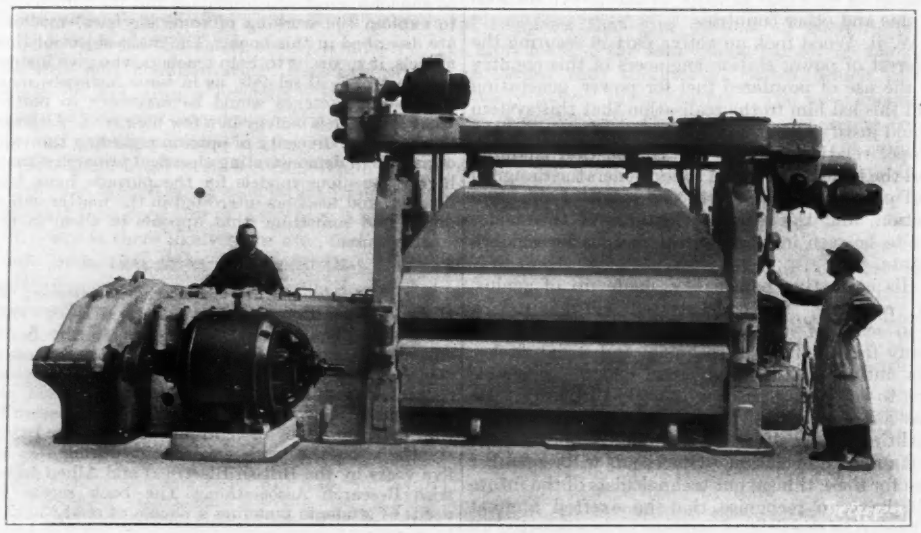


FIG. 1—SHEET METAL ROLLER LEVELLING MACHINE

We have received from the Central Tool and Equipment Company, Ltd., Central House, Upper Woburn Place, London, W.C.1, particulars of the "Lisse" sheet metal roller levelling machine, which it has introduced into this country. These machines are made in several standard sizes for high-speed working, with sheets from 0·008in. to 0·218in. thick and in various widths. Each machine has from fifteen to twenty-three rolls, and it is claimed that the use of so many rolls gives a sufficient number of deformations to the sheets to eliminate most of the internal stresses. The high-tensile steel rolls are relatively small, ranging between 0·787in. in the smaller and 3·74in. diameter in the larger machines. By using these small rolls the sheets are deformed round a very small radius to cause the elastic limit to be exceeded.

The rolls are supported at their rear against bending moments by counter rolls mounted in a series of separate assemblies. The lower counter roll assemblies are adjustable vertically within the machine frame and by their adjustment the main rolls may be deformed where required to give a greater deformation to any part of the sheets passing through the machine.

The upper rolls and counter rolls may be tilted with respect to the lower rolls and by this means the deformations to the sheets are made round radii of decreasing length, so that they leave the machine quite flat. In addition, the internal stresses imparted to the portions worked are progressively removed, thus greatly limiting cold working. As the machine is reversible, this tilting also permits sheets to be fed from either side.

In Fig. 1 may be seen the arrangement of one of the larger "Lisse" levelling machines. The lower cross frame of the machine forms a base on which the pillars are mounted and the pillar assembly is fixed to the cross frame by steel tie bars. The upper and lower cross frames are so designed as to be only lightly loaded during rolling operations and the general assembly of the machine is sufficiently rigid to eliminate deformation during working.

A reversible electric motor drives the main gear-box through a flexible coupling and reduction gears. From the gear-box, shown in Fig. 2, each of the main rolls is driven by a separate spindle through a universal joint. The use of universal joints permits adjustments to be made to the roll assemblies without interference with the drive. Lubrication in the gear-box is effected by either splash or chain.

As stated above, the main rolls are supported by assemblies of counter rolls and their arrangement may be seen in the drawing, Fig. 4. The counter rolls of the upper rolls are fixed, but those of the lower rolls are adjustable vertically. As may be seen from the bed of lower counter rolls shown in Fig. 3, each assembly is held in position by spindles, which pass through their housings and lock in brackets at either side of the bed. Each of these brackets is part of a cross member beneath the roller bed, and by means of wedges these members may be adjusted vertically. The wedge controlling each member is moved by a screwed shaft extending to a gear-box at the end of the machine. When it is required to adjust the height of any particular part of the bed, to deform the main roll, a selector in the gear-box engages the wedge concerned, and it is inserted or withdrawn by turning a hand wheel. The framework on which the upper roller assembly is mounted is supported between the pillars on a bearing on which it may be tilted with respect to the lower rolls. It is also possible to lift either end of the upper assembly to give an endwise displacement with regard to the lower rolls. In the case of the larger types of these machines, certain of the adjustments are done by small electric motors and gear-boxes. All the controls are at one end of the machine and therefore adjustments can be easily and rapidly made.

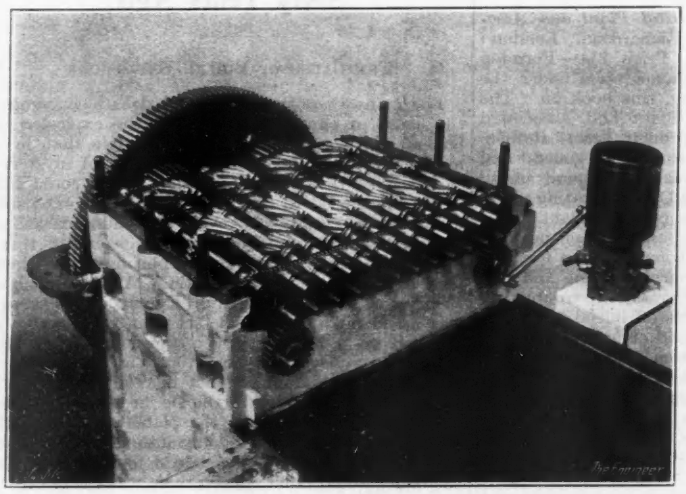


FIG. 2—GEAR-BOX

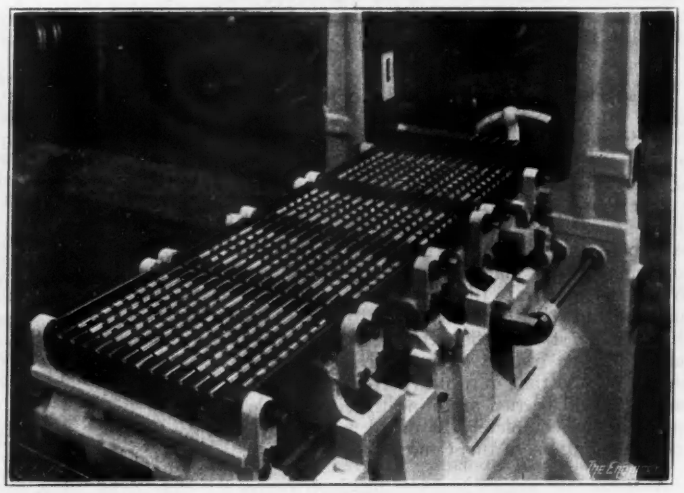


FIG. 3—LOWER COUNTER ROLLS

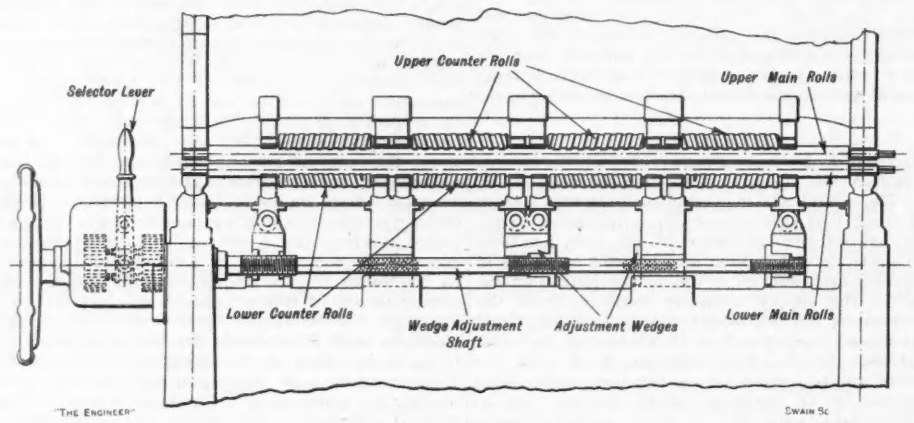


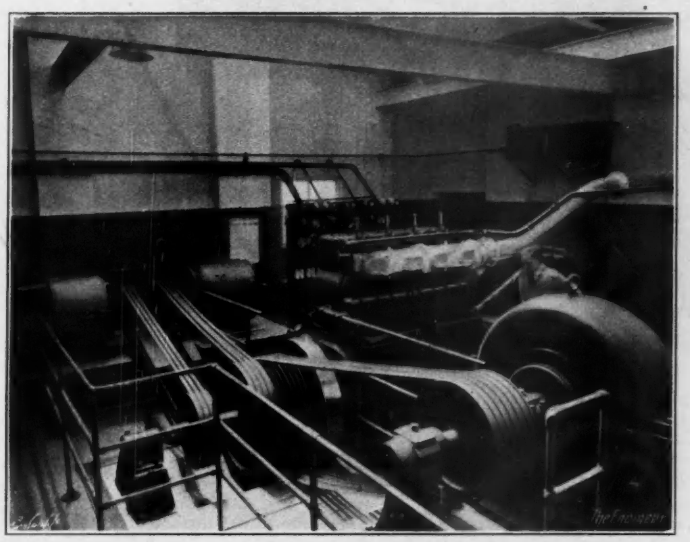
FIG. 4—ROLLER ARRANGEMENT

Works Power Plant at Timperley

AN interesting example of a recently completed independent works power plant is provided by the engineering works of the Wall Paper Manufacturers, Ltd., at Timperley, Cheshire, which is shown in the accompanying engravings. The works were founded about four years ago, and then consisted of one long shop with a length of 300ft. and a width of 30ft., power for which was provided by a horizontal oil-engine-driven generating set. With the rapid growth of the new works and increased production, it became necessary to consider the installation of new power plant which would meet the requirements of not only the present but the future.

A scheme was prepared by Mr. C. F. Copley, the assistant manager, and it was decided to drive the various electric generators by a four-cylinder Petter "Superscavenge" oil engine, having a designed

output of 250 B.H.P. As the works and the power house are situated in what has grown to be a residential part of Timperley, it was very necessary to take into account, and to avoid, the possibility of vibration, of which complaints had been received, when the old power plant was in operation. The problem was rendered more difficult by the presence of an unfavourable strata formation, but a satisfactory solution was obtained by the following method of foundation construction. The foundation was excavated to a depth of 21ft., when sandstone was reached. It forms an island, of suitable dimensions, to carry the engine unit. Round the foundation a cavity 3in. wide was left, and an outer foundation wall, 21ft. deep and about 2ft. 6in. wide, was built. Realising that water seepage might occur, drain outlets were constructed in the outer wall at a height of about 3ft. from the surface, so that water accumulating in the 3in. cavity would not rise above that level. It was intended to fill the cavity with cork blocks, in order to act as a further vibration damper, but this provision was not found to be necessary, as efficient results were obtained when the cavity became filled with the water provided by the seepage.



INTERIOR OF POWER HOUSE

COOLING TOWER, SILENCER AND TANK

The power station equipment comprises a Petter "Superscavenge" engine, with a multi-vee section pulley and an outer pedestal bearing, driving three independent generators, one of 85-kW and two of 50-kW capacity. As will be seen from our illustration, the lay-out provides ample room around the various units and gives a clear view of the switchboard, which is placed near the main entrance. The board was supplied by Dorman and Smith, Ltd., of Salford, and is fitted with main circuit breakers by J. G. Statter and Co., Ltd., and watt-hour meters by Ferranti, Ltd.

In addition to supplying electricity for power, heating, and lighting to the entire works, including a large engineering shop, which is 300ft. square and equipped with modern machinery of all types, the plant also supplies an adjoining factory of similar size, owned by the same company.

It operates 11½ hours per day and six days a week, during which time it supplies about 175 electrical horse-power in total to both factories. The current is generated at 460 volts, the average load being 100 amperes.

A small air compressor unit, which is required for charging the starting air receiver, is placed in one corner of the station. It comprises a two-cylinder horizontally opposed air-cooled Petter petrol engine, the second cylinder forming the compressor unit. Engine cooling is provided by the neat and compact cooling tower, immediately outside the station, as shown in the accompanying illustration.

As will be seen from the engraving we reproduce, the plant is very compact, and we are informed that the running of the engine is almost noiseless, with a smokeless exhaust, while the running costs are remarkably low.

The Limits of Theory in Electrical Machine Design*

By G. H. RAWCLIFFE

A PERIOD in an industrial design office made the author realise how wide were the discrepancies between the theory and performance of electrical machinery, and how many points of vital commercial and practical importance defied satisfactory theoretical treatment. Some of these points have been selected to illustrate why and how theory is sometimes insufficient. In a short abstract it has been necessary simply to show the nature of the problems, and to omit results of particular problems given in the original paper.

The number of variables in an electrical machine is very large, and before calculation can profitably be commenced a selection must be made of the predominant factors. It is in the making of this selection, rather than in subsequent deduction, that the real difficulty of a problem commonly lies. The examples given in text-books are, in fact, ready-made selections of the leading factors in electrical design, and the answers give the behaviour not of actual machines, but of idealised machines subject only to these selected effects. The errors correspond to the errors in the initial assumptions, and many discrepancies of performance arise from hidden assumptions in calculation.

In general it may be said that departures from calculated performance arise, theoretically, from simplification in calculating a major effect, or from ignoring a minor effect, and, practically, from manufacturing tolerances on theoretical dimensions. One very important cause of discrepancy is the tacit assumption that a sinusoidal function in space or time is a true representation of every alternating quantity involved in the calculation. This assumption is made since the sine wave is the only periodic function whose differential coefficients are of the same shape as the original function, but it is often far from true.

The problem in D.C. machines which is theoretically most troublesome is commutation. According to the classic theory the interpole windings are designed to nullify the armature ampere-turns and to neutralise the self-induced E.M.F. in the armature coils undergoing commutation. The inductance of the coils is, however, variable and uncertain, so that no precise estimate can be made of the requisite gap flux and interpole turns; the correct value can only be fixed by test. Some of the interpole turns may better be applied as a compensating winding fitted to the main pole tips and enclosing the armature, the magnetic axis of compensating and interpole windings being the same. The compensating winding "compensates" that part of the armature flux which completes its circuit through the main poles; the interpoles deal with the rest, and also supply the flux to oppose the armature self-induction. Interpoles and compensating windings thus divide two functions between them, and within fairly wide limits one can be strengthened by weakening the other. The ideal division of ampere-turns can, however, only be found by test, and it will vary with differing gap lengths and pole-tip shapes.

The classic theory takes no adequate account of brush material or size, commutator speed, current density, and the like. "Get the field form correct," so, in effect, runs the theory, "and the current may be drawn off from any brush you may care to fit on the neutral axis." A correct field form is a necessary, but not a sufficient, condition for good commutation and the further quantities of brush current density, &c., are settled only by experience, the aim being to use the smallest possible brushes and commutator. It is impossible to forecast from theory to what limiting density the present brush densities of 60–75 amperes per square inch might be increased.

Basic theory assumes a uniform current distribution round the periphery of the armature, but in fact the current is contained in small "packets" in slots, and much variation in commutation is produced by different slottings and by lamination of the conductors.

An example of classic theory being reversed in practice is furnished by compound-wound D.C. motors. In many text-books and among many practising engineers the idea still lingers that differential compounding is used to secure a level speed characteristic. Actually, owing to high flux densities and high armature loading, the armature magnetic field, in spite of interpoles, causes not merely distortion, but reduction, in flux, and many plain shunt motors would have a rising and unstable speed/load characteristic. It is usual, therefore, to fit either a compensating winding, which neutralises the armature more effectively than interpoles, or a light cumulative compound winding, often known as a series stability winding. Where heavy peak loads are expected a heavier compounding is fitted to give a normal compound-wound motor.

Differential compounding is only rarely used when, as in balancer sets, the same machine has to work either as a motor or as a generator, without alteration of the connections. Two machines coupled together may be stable even with the motor differentially compounded. It should be emphasised that the behaviour of generators is not the reverse of that of motors, since generator fields are also weakened by the saturating effect of armature reaction, which is independent of the direction of armature current flow. Hence generators are also cumulatively compounded for level voltage characteristics, but more strongly so than armature drop alone would require.

A serious, but incalculable, loss in D.C. machines is that due to eddy currents in the conductors, generated during their movement through the regions of non-uniform flux distribution at the tips of the poles. This loss is reduced by lamination of the conductors, and it is customary to laminate until the reduction of cross section is 15 per cent. The reduction of eddies by further lamination would not outbalance the increase in resistance.

To avoid the crawling of squirrel-cage rotors, the bars are skewed one stator slot-pitch. The skewing of bare bars led to increased rotor heating, and they are now usually insulated. The increased rotor heating arose from the connection through a good conductor of different parts of the rotor iron not in the same part of the stator field form. This eased the part of the "average" eddy current, and surprisingly large reductions of heating have been obtained through insulating the rotor bars.

These examples of extra eddy-current loss differ in that the first can be measured approximately on no load, but the second varies with load and cannot be measured; both defy calculation on any but an experimental basis. Stray load losses could only be measured by tests of the highest precision, measuring both input and output exactly. Hence the recognised method of estimating efficiency is "the summation of measurable losses," and an allowance is made for stray load losses. Their real importance lies not so much in the decreased efficiency as in the increased heating, and consequent reduced rating, which they cause. A loss of efficiency of 1 per cent. may be tolerable, when the heating caused by this loss is not.

Calculations are based on eddy and hysteresis losses in standard test pieces, but the magnetic condition of the iron is much altered by punching, the alteration depending on the ratio punched-area/punched-periphery, the condition of the punching tool, the mechanical state of the iron, the speed of punching, and so on. Tests can be made with particular specimens, but the variations of the conditions of punching cannot in practice be controlled. Further, the laminations are short circuited at the edges by burrs and by the machine frame; this causes extra eddies. There are also iron losses due to pulsation at tooth frequency. There is a time pulsation in reluctance and flux as the teeth change their relative positions, and a space pulsation of the flux, due to changes in the geometry (as distinct from the reluct-

* Abstract of paper read before the Mersey and North Wales Students' Section of the I.E.E.

ance) of the magnetic circuit. Theory shows that suitable slottings and a longer air gap will reduce these losses, but the magnitude of the change can only be roughly estimated. In the result, the iron loss is two or three times that calculated for eddy and hysteresis at fundamental frequency in the unpunched iron, and it is estimated largely from empirical data.

Here manufacturing discrepancies quite obscure any attempt at theoretical refinement. A large part of the magnetomotive force is used on the air gap, and 0·001in. error in stator bore and rotor diameter, in opposite directions, may be equivalent to 10 per cent. error in air gap length.

The calculation of leakage reactance is rendered difficult by both theoretical complexity and manufacturing errors. The leakage is controlled by the sizes of the gaps between teeth, by the air gap, and by the distribution of flux in these gaps. Even if the dimensions of these gaps were exactly known a precise solution would be impossible, but the practical uncertainties of a core of punched laminations make the matter doubly difficult. The end leakage, especially with machines of long coil overhang, is uncertain, because of the complicated shape, and hence all leakage formulæ are largely corrected by constants. It will often be found that the reactances of various members of a batch of machines, built to the same specifications by high-grade processes, differ considerably. This is particularly true of double squirrel-cage machines, on account of the depth of rotor slots.

The factor which theory is least competent to predict is heating. Any machine is an aggregation of many bodies, all of differing masses, densities, specific heats, conductivities, and emissivities; some parts have heat generated in them and some are only heated by conduction; heat flow is much altered by small differences in air spacing, and most machines are artificially cooled by fans. In the face of such facts as these, any attempt at precise prediction of temperature rise, from dimensions and physical constants alone, is obviously impracticable. Given the design data of a machine, one could estimate most of the performance data within 10 per cent., but an estimate of the temperature rise obtained in the same way would probably be 50 per cent. in error. A species of statistical calculation, based on results and rules obtained from similarly constructed machines, is all that it is profitable to attempt. Earlier treatises usually devoted a good deal of space to predetermination of temperature rise, but later ones simply outline permissible temperature rises, methods of measurement, &c., avoiding any suggestion that prediction is possible, except from experimental data. The process is almost inspired guesswork, but experience can lead to accurate results except with radically new machines.

Except descriptively, heating is an experimental subject; practically, it is of paramount importance. All machinery is sold under temperature guarantee, the limits not being in any way arbitrary, but based on previous experience that if the temperatures specified are exceeded the insulation will rapidly deteriorate. In most cases the heating limit is reached before the machine is overloaded mechanically. Hence improved methods of cooling have very great economic value. Efficiency can often be better reckoned from a commercial aspect as (horse-power per pound weight) than as (power taken out/power put in), and cooling has been one of the main factors in the increase of efficiency reckoned on the first basis.

It will thus be seen that the prediction of electrical machine behaviour is both theoretically and practically complex, and that undue refinement in dealing with a particular case cannot be justified. Analytical treatment of results from a particular machine is not valuable unless it leads to a future synthesis; that is, unless it assists in the prediction of the performance of another machine. The task of the designer is to be wise before the event, and not after, and the difficulties of this have been outlined. When they are considered even such accuracy as is obtained is perhaps remarkable.

Seed-Heating Kettles

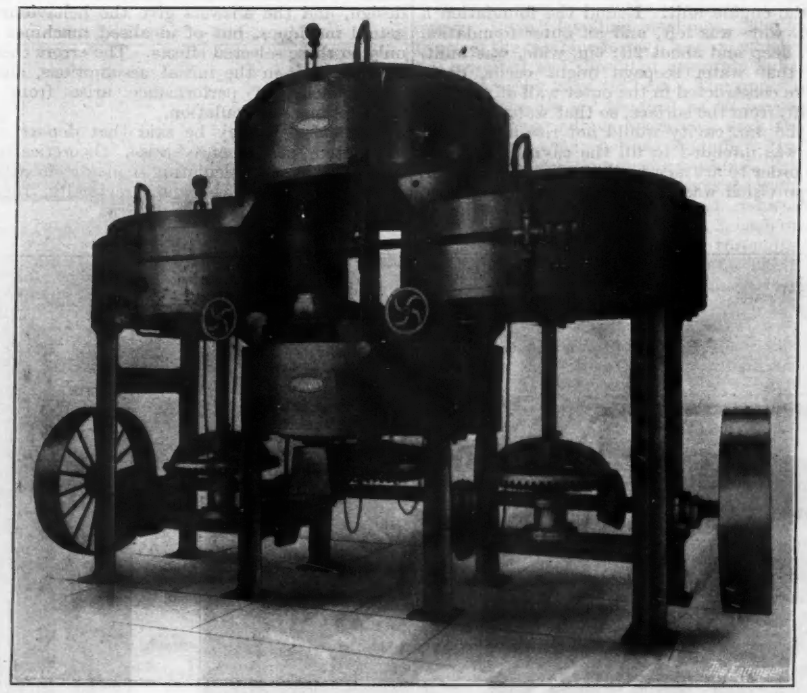
In the accompanying engravings are illustrated two types of seed-heating kettles manufactured by Rose, Downs and Thompson, Ltd., of Old Foundry, Hull. These kettles are made for the purpose of carrying out one of the essential operations in the process of oil milling for the extraction of vegetable oils, and they form one item amongst many types of machines made by the firm for use in oil mills and refineries. The operation of cooking and tempering the meal of oil-bearing seeds and nuts in the process of oil extraction by pressure has an important influence upon the yield of oil obtained by the pressing operation, irrespective of the type of press employed or the amount of pressure exerted.

In constructing oil kettles the firm uses mild steel as a material for the bodies, electrically welded throughout, thus eliminating the risk of leakage frequently attributable to riveting. According to requirements, the kettles are either steam-jacketed both at their bases and sides or at their bases only. All outlets and bearing blocks extending through these steam jackets are of steel, welded in position, with all flat surfaces amply stayed across the steam spaces. A point to be noted in the design is that the kettle bottom with its steam jacket intact is easily detachable from the body, and, when the body is steam-jacketed, too, both steam jackets are entirely independent. Thus, since these steam jackets function independently, it is possible in cooking to utilise the heat of either the bottom jacket or the side jacket, or to combine the heat of both, according to the requirements of the material being treated; whilst the easy detachability of the kettle bottom from the body renders the renewal of the bottom wearing plate a comparatively simple operation, and, if worn, the kettle can thus be restored to full efficiency at low cost.

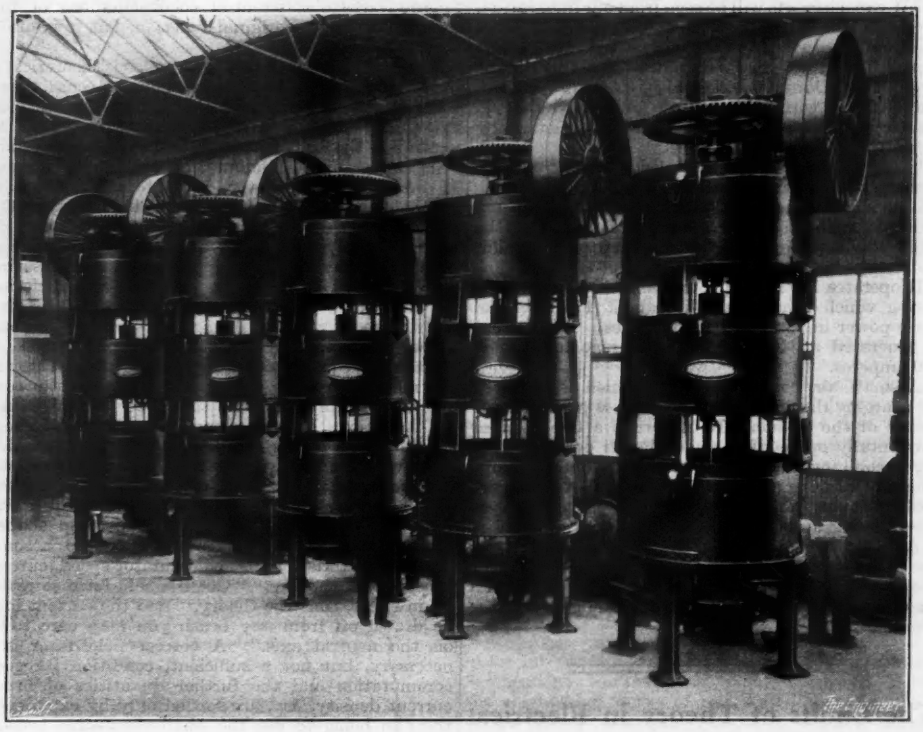
In the multi-stage kettles, such as are illustrated, the combined weight of the vertical shaft, stirrers, and bevel wheel is carried by a large heavy-duty ball thrust bearing in an oil and dust-tight housing on the top of the unit where it is easily accessible, the ball thrust and its adjacent radial bearing being fitted with pressure grease lubrication. This provision eliminates all risk of the falling of the shaft with its consequent disturbance of the upper driving gear and the danger of the stirrers fouling the kettle bottoms. A radial bearing is fitted at the bottom of the shaft, and in multi-kettle units radial bearings are fitted to each kettle.

Stirrers are of forged steel keyed to the shaft, and, working close to the kettle bottoms, prevent meal adhering and becoming burned. Driving gears are of ample proportions, machine moulded, and are securely keyed to shafts. The horizontal shafts run in roller bearings, and where fast and loose driving pulleys are fitted the necessary belt-striking gear is supplied. In cases where the drive is high above floor level, as with multi-kettle units, the belt-striking gear is operated by hand chains from the floor. When required, the stirrer gear of the kettles can be arranged to be driven by electric motors, coupled through speed reduction gearing.

In multi-kettle units of the open type, the meal outlets from one kettle to the next lower one are fitted with adjustable regulating slides to control the rate of discharge, placing the speed and effectiveness under perfect control. In multi-kettle units of the enclosed type the height of the meal in each kettle is automatically controlled, and in all multi-kettle units the intermediate meal outlets are disposed around the unit, compelling the meal to follow an extended track and preventing it falling straight through the kettles. The cooked meal discharge outlet in the bottom kettle is arranged to suit whatever feeding device is required by the machine receiving this meal; for example, a moulding machine, cage



EXTENDED UNDER-DRIVEN FOUR-UNIT KETTLE



THREE-HIGH OPEN OVER-DRIVEN KETTLES

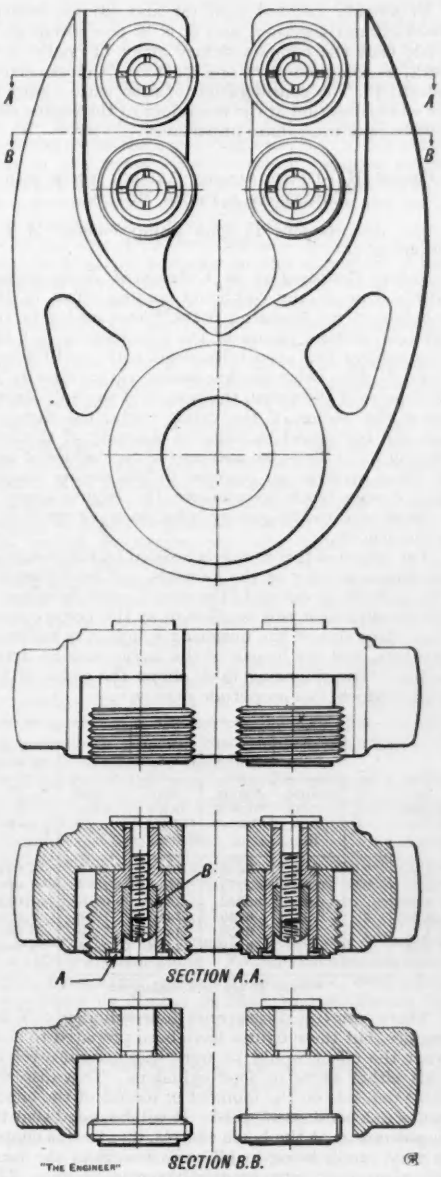
press, oil expeller, &c., and any special form of meal outlet can be supplied.

The standard equipment of the kettles includes an automatic meal level indicator for each kettle, steam pressure gauges, safety valves, condensate drains with steam traps, meal-damping apparatus in each kettle for adding moisture to the meal in the form of steam, steam valves having graduated dials and pointers for the close regulation of the moisture, and steam valves with graduated dials fitted to the steam jackets which control the jacket heat. Automatic heat regulators, dial thermometers, and recording thermometers can also be fitted when required.

When the height of the mill building is restricted, or where it is not possible to accommodate a large kettle unit in which the kettles are superimposed one above another, large capacity units can be supplied with the kettles arranged in extended form and driven from below. Such an arrangement is illustrated in the upper engraving, showing a four-kettle unit of the extended type. The lower engraving illustrates a series of three-high open kettles, driven from above. In the open kettles the range consists of types up to three-high, with open spaces between the kettles. In the close type the arrangement can be up to three-high with separate kettles bolted together. In addition, there is the totally enclosed or continuous type, up to five-high, in which there is a one-piece outer casing fitted with access doors to each compartment, with steam jackets in the bases only of the compartments.

Roller Caliper Thread Gauge

IN the accompanying drawings is shown the construction of a new type of thread gauge, manufactured by Brown Brothers (Aircraft), Ltd., of Great Eastern Street, London, E.C.2. It is known as the "Aggra" caliper screw gauge, and is so designed that right or left-hand threads can be checked with the same tool; furthermore, the use of rotating rolls for the gauging surfaces is claimed to reduce wear to a negligible amount, and therefore eliminates the necessity of periodical regrinding.



THREAD GAUGE

As is illustrated in the engraving, two pairs of rolls are mounted in a frame made of cast iron, which is claimed to be fully aged and of such construction as to prevent distortion occurring. The top pair of rolls has a series of annular rings, forming a "go" gauge, the width of which is not less than the normal length of engagement of the thread. When passed through this first set of rolls, the work is checked for maximum, full, core, and effective diameters. Each of the lower pair of rolls has formed on it two and three annular rings, respectively, designed to clear the roots and the crest of the thread to be gauged. These rings make contact only on the flanks of the threads, and form a "not go" gauge, and check the work for minimum effective diameter. It should be noted that the rings on the rollers are annular and not of helical shape. Both sets of rolls are free to rotate, and to float slightly on their axes, and therefore they accommodate themselves as regards alignment with the work.

In order to adjust the gauge to suit varying tolerances, each roll is mounted on an excentric bush A, which can be rotated in its bearing in the frame. The desired setting is made with the aid of a plug gauge made to the required limits; the bushes of the "go" rolls are turned until the "go" end of the plug will just pass through and the nuts B are then tightened, locking the setting. The "not go" rolls are then similarly adjusted. It is pointed out by the manufacturers that the correct alignment of the gauging rolls is dependent on two locations only, namely, those of the excentric bushes in the frame, and therefore the number of points of adjustment is reduced to a minimum. The bush is held firmly to its seating, and therefore, when adjusting the gauge, there is no tendency for it to be displaced. Other advantages are claimed for the design; the locking device is a separate component, forming no part of the adjusting bush; the adjusting bushes are fully sunk into the gauging rolls, enabling the gauge to be used right up to a shoulder; and the gauge can be readily sealed, so that it becomes impossible to tamper with the setting.

Shunting Locomotive Test Figures

THE introduction of an oil-engined 0–4–0 type shunting locomotive, designed and built by the Associated Equipment Company, Ltd., was officially announced in November, 1938, and was fully described and illustrated in these columns on page 680, December 16th, 1938, and in the issue of January 6th, 1939.

In order to test the locomotive in actual service conditions, it has been employed within the precincts of the company's factory at Southall since October of that year. It is now possible to give figures relating to the work it has so far accomplished, as well as those obtained from tests held recently, by permission of the G.W.R., over that company's Southall and Brentford branch line. These tests were undertaken in order to determine the maximum capabilities of the locomotive.

Before quoting the two sets of figures it may be well to repeat the principal features and dimensions of this unit. Designed primarily for work in industrial sidings, the locomotive is fitted with an A.E.C. four-cylinder engine of 120 mm. bore and 146 mm. stroke, developing 78 B.H.P. at 1700 r.p.m. It has a gear-box of the four-speed each way pattern, incorporating a countershaft drive to the leading and trailing axles. Axles are of the cannon type carried on two large diameter taper roller bearings and are driven independently from the gear-box by universally jointed shafts. The drive itself is of the gear and bevel double reduction type. For retardation a screw-down hand wheel, with a link adjustment between the column and cross shafts, actuates brake shoes on all four wheels.

The weight of the locomotive is 13 tons 5 cwt. 2 qr., and it has the following principal dimensions:—Length over head stocks, 15ft. 1½in.; length over buffers, 18ft. 1½in.; overall width, 8ft. 1in.; overall height, 11ft. 4in. Maximum speed is 14 m.p.h., and tractive effort 8850 lb.

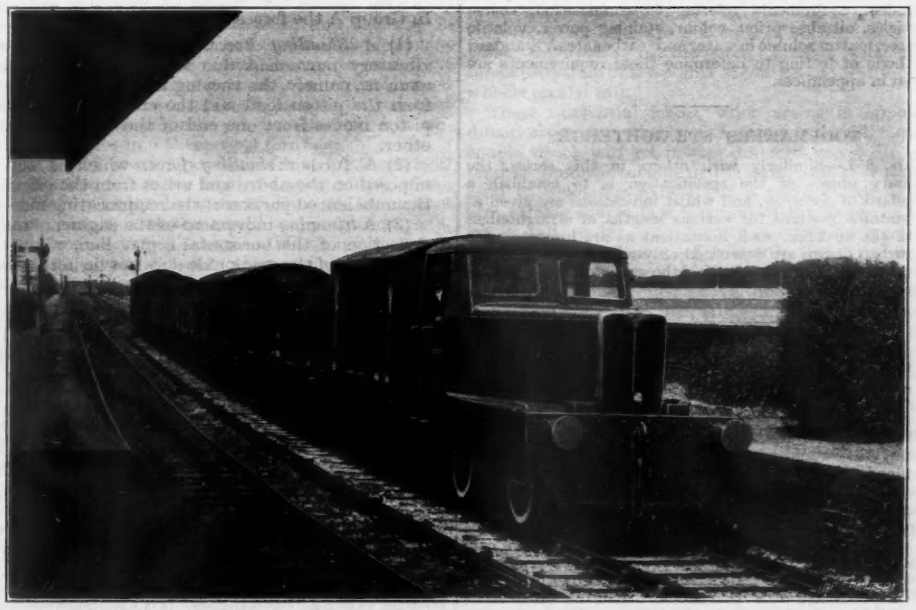
Used for marshalling and hauling full and empty trucks to and from a siding adjacent to the Southall factory premises, the locomotive in its first eight months of service has run 976 miles in a driving period of 563 hours. It has hauled 1462 loaded and 139 empty trucks inwards and 616 loaded and 972 empty trucks outwards. This work has involved a total fuel consumption of 277 gallons, equivalent to 3·52 miles per gallon, or 0·492 gallon per working hour.

Three tests were undertaken on the Southall and Brentford branch line. In order to obtain accurate weights, the first was carried out with a load of twelve empty trucks and a brake van, and covered a distance of 3½ miles over an average rising gradient of 1 in 290. The test began on half a mile of line rising at 1 in 110 and finished on a section 0·9 of a mile in length rising at 1 in 102. The weight of the train, excluding the locomotive, was 96 tons 14 cwt.; 19 min. were absorbed in travelling over the distance mentioned, which gave an average speed of 11 m.p.h.

The second test was carried out on a level siding with a train of thirty-two loaded trucks, weighing approximately 350 tons. The test was curtailed owing to the length of the line available, but it was sufficient for a speed of 4 m.p.h. to be obtained, and showed that second speed could be engaged before 50 yards had been covered.

In the third and most severe test the load was made up to seventy-seven trucks, with a gross weight of 900–1000 tons. Despite this exceptionally heavy train, a speed of 2–3 m.p.h. was reached before the limited length of line available had been traversed.

The second and third tests were carried out in both directions. In all three cases it was shown that the locomotive could haul loads greatly in excess of those for which it would be required in normal shunting work over industrial sidings. The accompanying engraving illustrates the locomotive and a load of trucks on the testing branch line.



OIL-ENGINED LOCOMOTIVE ON TEST

Thermostatic Bimetals

IN many applications of thermostatic bimetal, such as temperature control and safety devices fitted to electrical domestic appliances, the bimetal strip is caused to deflect by heat transmitted from its surroundings. In the control of electric currents, however, it is often convenient to incorporate the bimetal element in the circuit, so that it is directly heated by the passage of the current. This arrangement depends, of course, on the principle that a metal having high electrical resistance becomes heated when an electric current is passed through it, the heat developed, and consequently the movement of the bimetal element, being proportional to the current passing. Electric cut-out switches represent an interesting application of this principle, and the value of

employing bimetals made to electrical resistance specifications will readily be appreciated.

We are informed that Henry Wiggin and Co., Ltd., of Thames House, Millbank, London, S.W.1, have recently introduced a series of twelve grades of such metals, known as Wilco-Wiggin resistance "Thermometal," specially developed to satisfy the requirements of the electrical overload protective devices. They provide, it is claimed, a wider range of resistivity than has hitherto been available, the figures varying from as low as 5 microhms up to 93 microhms per cubic centimetre. These materials have been carefully graded according to the requirements of various designs of thermal overloads, and the temperature/deflection constants are stated to be approximately the same throughout the range.

High and uniform deflection is claimed to be obtained with the minimum rise in temperature, thus facilitating calibration and rendering manufacturing tolerances less critical, and the good mechanical strength of this series of bimetals enables the blade to operate the tripping mechanism without undue flexing, and without overstressing the element.

These bimetals consist of two materials—usually nickel alloys—which have different coefficients of expansion, and which are firmly bonded together along their faces of contact. Change in temperature causes the composite material to bend, and this movement can be made to operate various types of mechanical devices or electric switches. The metals can be supplied in the form of strip, coils, helices, and other shapes.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

STANDARD COPPER CONDUIT AND FITTINGS FOR ELECTRICAL WIRING

No. 840—1939. This specification prescribes the quality of the copper or copper alloy from which the conduit should be made, and gives details of manufacture and tests. A table has been included giving a comparison of the inside and outside dimensions of copper conduit, as against those for steel conduit covered by B.S. 31. Conduit boxes, if made of copper or copper alloy, are required to comply with the dimensions laid down in B.S. 31. In order that steel, malleable, or cast iron boxes may be used with copper conduit, details of suitable couplers are also given. The specification also gives details of other copper fittings, such as saddles, clips, &c. These fittings differ slightly from those used for steel conduit on account of the slight differences in external diameter of the copper and steel tubing.

HYDRATED OXIDES OF IRON

No. 851.—In the course of the revision of series of British Standards for Pigments for Paints, it was felt that there was a need for a standard to provide for chemically prepared hydrated oxides of iron, which are now being increasingly used. The specification provides for marigold, maroon, and yellow pigments of the pure and reduced type. The form of the specification follows that of the other British Standards for Pigments, and includes requirements relating to composition, coarse particles, oil absorption, colour, staining power, volatile matter, matter soluble in water and carbonates. Standard methods of testing to determine these requirements are given in appendices.

TOOLMAKERS' STRAIGHTEDGES

No. 852.—Similarly with others in this series, the primary object of the specification is to establish a standard of accuracy, and whilst indications are given as to suitable sections for various lengths of straightedges from $\frac{1}{2}$in. to 12in., such limitations as are imposed with regard to design are concerned only with details affecting the accuracy and suitability of the straightedges for their intended use.

MORRIS MOTORS, LTD.—Cowley, near Oxford, the home of Morris cars, now has another claim to fame as the place where 15in. of "rainfall" is recorded every hour of the working day. Fortunately this torrential downfall does not extend over the whole of the district, otherwise the countryside would be almost permanently flooded, but is confined to a section of the Morris factory, where an artificial rain plant has been installed. The object of the plant is to test thoroughly the waterproof qualities of the cars before they leave the factory—a point of importance in view of the fact that of the total number of saloon cars made, no fewer than 86 per cent. are of the sliding or sunshine roof type. It was discovered, according to "Kempe's Engineer's Year Book," that the worst short rainfall period ever recorded in Great Britain was at Norwich, when 0·52in. was registered in about five minutes. It was decided to standardise the water output from the storm test at 15in. per hour, or almost $2\frac{1}{2}$ times this amount. As each car enters the booth 15,000 jets of water are cascaded over it from all angles at a rate of 100 gallons per minute. Such intensity immediately finds any weak spots not only in the roof, but tests the watertightness of the windscreen and the windows, the efficiency of the drip moulding and the effectiveness of the bonnet sealing for preventing water penetrating to the power unit. For experimental purposes the pressure of the water is increased tenfold.

The Disturbing Forces in a Locomotive*

No. I

DEFINITIONS

IN practice, terms to describe movements of engines on the track are often loosely used to refer to more than one movement; it is advisable, therefore, to define such terms as follows:—

Oscillation.—This inclusive term is generally used to describe movements of the engine in any plane.

Nosing.—Transverse oscillation of the engine on the track about a vertical axis. Pursuing a sinuous path along the track.

Rolling.—Transverse oscillation of the engine on its springs, about a longitudinal centre line.

Hunting.—The two movements defined above rarely occur separately, but are generally found acting together in varying proportions. The resulting oscillation is described as hunting.

Lurch.—One semi-amplitude of movement in the action of hunting, viz., an individual deflection from the centre line towards one or other of the running rails.

Shuttling.—Oscillation in a fore-and-aft direction parallel to the track.

Pitching.—The front and back ends of an engine alternately rising and falling about a transverse horizontal centre line; this is sometimes referred to as galloping.

Trimming.—A settling down of the engine, either at the front or rear end, so that the line of the footplate is no longer parallel to the track.

General.—In this chapter we intend to deal with the technical aspects of ten disturbing forces, to which a locomotive is subject when running on the track. We shall distinguish between those which primarily affect its stability as a vehicle and those which have only a secondary effect. We attempt a rational explanation as to how hunting occurs, and of the circumstances in which it will either die away or build up to undesirable proportions. For reasons set out in the text, the matter is not dealt with mathematically, and, in avoiding such treatment, we have had regard to the valuable investigations of Carter[1] in England, Cain[2], Langer and Shamberger[3] in America, Marié[4], Levi[5] and Rocard[6] in France, amongst others, who have approached the problem from that aspect. Their work has pointed the way, but for immediate results, which can be put into practice forthwith, less rigid methods of analysis have to be pursued.

Summary of Disturbing Forces.—These may be divided into three groups:—

A. Those which act solely in a longitudinal direction and do not therefore affect the problem at all.

B. Those which by their direction have a tendency to produce hunting, but, due either to the period at which they act, or to the small amplitude which they attain, have little practical bearing on the problem.

C. Those which have a direct bearing on hunting and the resulting flange forces.

In Group A the forces concerned are:—

(1) *A Shuttling Force*, causing a fore-and-aft vibratory movement due to the uneven turning moment, namely, the varying tractive effort arising from the piston load and the crank angle, as the piston moves from one end of the cylinder to the other.

(2) A further *shuttling force*, which is superimposed on the above and arises from the effect of the unbalanced portion of the reciprocating masses.

(3) A *trimming* movement of the engine, namely, deflection of the horizontal centre line, when the centre line of the crank axle does not lie in the same horizontal plane as the draw gear.

In this group are mentioned disturbances which only affect the engine in a direction parallel to the track, and as they have no bearing on the present investigation, further reference will not be made to them.

In Group B the forces arise from:—

(4) *Surging Effect* of the unbalanced masses acting in the different planes of the several cylinders, which cause a couple tending to make the engine oscillate transversely about a vertical axis.

(5) *Rolling*, which is set up by the vertical reaction of the crossheads on the slide bars.

(6) *Pitching*, which is set up by slide bar pressure being accompanied by an equal downward thrust at the crank axle.

(7) *A Nosing Couple*, which may also be set up by the variation in piston pressure on the two sides of the engine at any one time; this is effective if there is twist on the axles due to this piston pressure, or if there is longitudinal play in the boxes.

This group comprises the disturbances arising from the function of the engine as a power unit; they would affect the engine even if it were slung clear of the rails by a crane. It will be shown that these disturbances have little direct bearing on the question of flange forces and track distortion; they are dealt with fully, in order to demonstrate this fact, as misunderstanding sometimes exists.

In Group C the forces arise from:—

(8) *Periodic Nosing*, which is set up by the coning of tyres, by transverse flexibility of the frame and wheel centres of the engine, and by irregularities in line and level of the track under load.

(9) *Rolling*, which is set up by track depressions under load, and is affected by stiffness of the springs, by the transverse moment of inertia of the engine, and by the transverse spacing of the axle-boxes.

(10) *Centrifugal Action* during the passage of an engine round a curve.

As already pointed out, (8) and (9) are nearly always found together, and it is in this group as a whole that the complementary effect of engine and track, as components of one machine, is most clearly indicated. The consideration of this, with regard to the whole question of the behaviour of the engine as a vehicle, is of immediate importance.

GROUP B.—DISTURBANCES ARISING FROM THE ENGINE AS A PRIME MOVER

The disturbances in this group consist of the following:—

Nosing Couple Due to Unbalanced Reciprocating Parts.—Due to the combined surging effect of the unbalanced reciprocating parts, forces acting in the different vertical planes of the cylinders are set up. This subject has been fully dealt with by Professor Dalby.[7] The value of this couple varies directly as the square of the speed, the weight of the unbalanced parts, the radius of the crank circle, the distance between the cylinders, and the obliquity of the connecting-rod. Thus, an increase in the values of any of these involves an increase in the nosing couple. This couple tends to oscillate the engine about a vertical axis, the frequency being once per revolution of the wheels.

The action of this couple is resisted by the weight of the engine resting on the journals, and by its inertia. It is possible to calculate the actual value in inches of the amplitude of this oscillation at the bogie centre, since the value of the initiating couple, the radius of gyration, and the length of the engine can be determined. The following table shows the order of the values which this amplitude attains:—

Class of engine.	No. of cyls.	Weight of unbalanced reciprocating parts, lb.	I for engine, tons-ft.	Distance between C. of G. and bogie pin, feet.	Sprung weight, tons.	Displacement on each side of C.L., inch.
"X A"	2	209	3616	13·2	49·6	0·024
"X C"	2	291	7775	15·1	75·8	0·020
"X B"	2	281	6542	14·6	69·6	0·022
"X B"	3	253	6750	14·6	72·0	0·020
"X B"	4	238	6750	14·6	72·0	0·007
"X B"	2	570*	6542	14·6	69·6	0·045

* Only 33 per cent. balanced.

There are no three and four-cylinder "X B" engines, but these figures have been prepared to show what the effect would be were these engines rebuilt with either three or four cylinders. This displacement depends on the moment of inertia of the engine and is independent of speed. It will be noted that the displacement at the bogie centres, due to this couple, is very small, being in all cases less than the usual side clearances between axle-boxes and horns. This is true even in the case where a very small proportion of the reciprocating masses have been balanced. Moreover, the above values ignore the effect of friction, which will tend to reduce the displacement still further.

As already stated, the frequency is once per

* Chapter III of the Report of a committee appointed to inquire into the purchase and use of "Pacific" locomotives in India.

[1] "The Electric Locomotive," "Proceedings," Inst. Civil Engineers, 1916; "On the Action of a Locomotive Driving Wheel," "Proceedings," Royal Society, 1926; "On the Stability of Running of a Locomotive," "Proceedings," Royal Society, 1928; "Running of Locomotives with reference to their Tendency to Derail," "Proceedings," Inst. Civil Engineers, 1930.

[2] "Safe Operation of High-speed Locomotives," "Transactions" of American Society of Mechanical Engineers, 1935.

[3] "Lateral Oscillations of Rail Vehicles," "Transactions" of American Society of Mechanical Engineers, 1935.

[4] "Traité de Stabilité du Matériel des Chemins de Fer" ("Treatise on the Stability of Rolling Stock"), Pub. Ch. Beranger, Paris, 1924.

[5] "Etude Relative au Contact des Roues sur le rail" ("A Study of the Contact Between Wheel and Rail"), *Revue Générale des Chemins de Fer*, February, 1935.

[6] "La Stabilité de Route des Locomotives" ("The Stability of Locomotives on the Track"), Pub. Herman et Cie, Paris, 1935.

[7] "Balancing of Engines," published Arnold, 1929. Bridge Stress Committee's Report, 1928.

revolution. Stated in seconds, the values are :—

Class of engine.	Period in seconds at speed.		
	20 m.p.h.	45 m.p.h.	60 m.p.h.
"X A"	0·53	0·25	0·18
"X B"	0·66	0·29	0·22
"X C"	0·66	0·29	0·22

The above values are well below the observed natural nosing period of the engines concerned, namely, 0·75 to 1·0 second at 60 m.p.h. These considerations show that there is little to choose between two, three, and four-cylinder engines, so far as the nosing effect due to reciprocating parts is concerned; moreover, the percentage of the reciprocating parts which are balanced has no appreciable effect on the nosing tendency, although there may be a slight possibility for this to build up, when the nosing period is an odd multiple of the natural engine period. A multi-cylinder engine, however, does produce a reduction in hammer blow and greater evenness of turning moment.

Rolling and Pitching Due to Reaction of Crosshead on Slide Bar.—A rolling couple is set up due to the variation in slide-bar pressure during a revolution. This pressure varies according to piston thrust, corrected for inertia and angularity of the connecting-rod for every portion of the stroke. To this is added, or subtracted, the effect of the further reaction due to the dynamic effect of the connecting-rod itself, namely, slide-bar hammer blow.

At the same time the resultant upward force at the front end of the engine causes a longitudinal galloping or pitching action, due to the pressure being accompanied by an equal downward thrust on the crank axle. The arm of this couple is the length between the centre of the crosshead and the centre of the crank axle, a distance continually varying with the position of the crosshead.

Both these forces have to be resisted through the bearing springs. Stiffer springs reduce the amplitude of movement in each case. The period of oscillation is twice per revolution, and the amplitude of movement increases with the piston load, the distance between cylinders, and the obliquity of the connecting-rod. It will be less with stiffer bearing springs, and as the moment of inertia of the engine increases. It decreases as the speed increases, due to the reduction in the mean effective steam pressure in the cylinders, unless the slide bar hammer blow increases at a greater rate. This effect influences the riding of the engine only at very low speeds.

Couple Due to Piston Thrust.—It is commonly thought that, in addition to the disturbing forces described above, there is also another nosing couple arising from the varying piston pressure, which acts on the axle-box guides, and which is continually altering in value and direction on either side of the engine. This, however, is not the case, if all the parts concerned are rigid. The forces and reactions concerned are within the framework of the engine. The force of the steam on the piston reacts through the cylinder attachment to the frame, and through the axle on to the same frame *via* the hornblock attachments. The variations in pressure will cause stress in the axle and frame, but will not produce a couple tending to slew the frame in relation to the track.

A nosing oscillation can only occur from this cause if the inequality in loads on either side of the driving axle produces a torque in the axle sufficient to twist it. There will obviously be such a torque; but axles are designed with sufficient stiffness to avoid twist of any appreciable value from this cause. Moreover, if there were a large amount of longitudinal play between the axle-boxes and the horns, it might be possible for the axle to get out of alignment, and thus cause a similar oscillation; but usually the amount of play at this point is insufficient to allow such an effect to take place.

The effect of the uneven piston pressure on the two sides of an engine is reflected in a linear shuttling effect, giving variations in draw-bar pull; whilst the visible oscillating effect, so often seen on outside cylinder engines working hard at low speed, arises from the slide-bar reactions already dealt with. The foregoing disturbing forces have no practical influence on the problem of hunting, a fact which can be verified by observing the behaviour of engines on a stationary test plant. Practical demonstrations, of this, by slinging engines from a crane, were made in Germany by Nollau in 1848, and in France by Le Chatelier in 1849 and by Baudry in 1890.

GROUP C.—DISTURBANCES WHICH IMMEDIATELY AFFECT THE ENGINE AS A VEHICLE ON THE TRACK

General Considerations which Concern the Behaviour of Engines on the Track.—In the early days of railways in all countries, sinusoidal deformations of the track have often been observed after the passage of certain engines, and derailments have resulted from time to time. The engines concerned were not so heavy as modern ones, nor was the track so strong as it is to-day. In France, for example, before the war, certain engines which caused such distortion did not weigh more than 40 tons, and ran at comparatively high speed on rails weighing 60 lb. per yard; the same kind of engine and track is used on branch lines to this day, generally at lower speeds. In England, similar cases with relatively light engines have also been referred to in Chapter I.

It is evident, therefore, that, as this kind of track deformation is not new, it has not been brought about solely by the advent of heavy locomotives. It is rather due to the fact that certain engines, whatever their weight, can develop flange forces of greater magnitude than can be withstood by the particular track on which they run; in this connection, the heavier the engine, the better the adhesion between sleepers and ballast, and, consequently, the greater is the force required to distort the track laterally.

Records of derailments show that the actual cause is often unsatisfactorily established. In many cases the engine has been found to be in good order, and without any defects which appeared to contribute to the occurrence. With regard to the track, it is often possible to examine only the sections ahead of, and behind, the site of the accident, and here again nothing abnormal may be found.

But on close examination, and with the knowledge gained from continued experience, it sometimes transpires that the engines concerned, although not heavy, were of a type known to have a tendency to cause transverse track deformation; they either had no guiding wheels, or, where these existed, there was ineffective side control, usually in conjunction with a large overhang at front or rear.

With modern engines, having guiding wheels, cases of sinusoidal deformation of the track are rarer than in the early days, but none the less a certain number have occurred. In some cases, as already mentioned, the engines have been condemned or radically altered, but in others the conclusion was reached that excessive speed, or local weakness of the track, was the main contributory cause.

Generally speaking, in the many different engine designs all over the world, designers have arrived at an arrangement, based on engineering instinct and experience, which has been quite satisfactory in practice. Due to trials made recently in several countries, it is now possible to visualise what is necessary to improve the running of engines on the track, and thus to avoid lateral deformations.

To the best of our knowledge, however, the actual mechanical process by which track distortion occurs is not yet exactly known. Mathematical theory has been used to work out equations of motion, but these have been so complicated as to be insoluble. Moreover, to make calculation possible, it has been necessary to make numerous assumptions, in order to allow of the possibility of integration and final solution. But these assumptions, however carefully they are based, have had the effect of altering the interpretation of the problem, and therefore the results obtained have not up to the present been of great assistance.

As an example of this, the Central Standards Office had, before our arrival, been attempting to gain some information on the critical speeds of hunting of "X" class "Pacifics," based on the theoretical and mathematical research of certain investigators, to which reference has already been made. In endeavouring, however, to apply the formulæ which have been worked out, differences were found in the assumptions which had been made, principally affecting the way in which the lateral action of the wheel on the rail was treated, and the way in which the amount of effective side displacement was considered. This variation in assumptions made a material difference in the critical speed obtained by the two methods, and indicated that practical results can not yet be obtained by substituting values in a theoretical formula.

This is, of course, no discredit to mathematical investigators, but arises from the very nature of the problem in which all the main elements, locomotive frames, wheels, and the track itself, are not rigid, but elastic in a varying degree. We do not therefore propose to give a definite explanation of so complicated a phenomenon as distortion of the track, but we will try to consider the matter as logically as possible, based mainly on experimental findings, checked by the recorded circumstances of various accidents and by our own observations in India.

As in the early days most of the engines had no guiding wheels, deformation of the track can obviously not be attributed to that feature. Even on engines with guiding wheels, trials made recently for assessing flange pressures have shown that generally it is the coupled wheels which bring about the highest reactions. It is evident that neither track nor engine can be perfect, but the better the one, the less perfect may be the other by a corresponding amount. If the total of the imperfections of track plus engine exceeds a certain value, the sequence of events, depending on speed, the state of the rail, &c., is, first, an abnormal movement of the engine on the track; secondly, deformation of the track itself; and thereafter even derailment.

Movement of a Single Pair of Wheels on the Track.—If it were possible for the flanges of the wheels to remain in permanent contact with the rails, and if track, wheels, and axle could be perfectly rigid, then there would be no problem of lateral oscillation. As a practical necessity, however, some clearance, varying in different countries is always left between flange and rail. Because of this clearance, the two wheels on an axle cannot make lateral contact with both rails simultaneously. The movement of wheels and axle along the track takes the form of a series of successive contacts between flange and rail, and of rebounds from one side to the other at variable distances. If this movement occurred on a perfect track, and was solely due to the coning of the tyres, the path followed by the wheels would be a sine curve, the length of wave remaining constant irrespective of speed, but depending upon the degree of coning of the treads, the diameter of the wheels, and the gauge.

In practice, however, the track is not perfect, and there are a number of causes which, acting either singly or in combination, alter the form of this lateral movement. The principal causes are :—

(*a*) Irregularities in gauge and level of the track under load, which tend to direct the pair of wheels towards one rail or the other.

(*b*) Irregularities in wear of the tyres and rail, and therefore in the effect of the coning of the tyres.

(*c*) Differences in the diameters of the wheels on the same axle.

When the amplitude of the lateral oscillation, measured from the centre line of the track, exceeds the clearance between flange and rail under load, and each time that a flange strikes a rail and is deflected towards the other, a force is exerted. The magnitude of this force depends on the weight of the wheel and axle assembly, and on the transverse velocity with which the flange strikes the rail. This velocity, for a given running speed, is related to the total amount of side movement of the wheels and axle, the movement being made up of the static clearance between flange and rail, plus any elastic deformation in wheel, axle, and rail.

Movement of Several Pairs of Wheels United Under One Chassis.—We will now consider several wheels and axles on which is mounted a locomotive frame without carrying wheels, viz., an engine such as the 0–6–0 type. Lateral oscillations arising from the passage of the individual wheels and axles along the track will be imparted to the chassis through the wheel boss face, axle-box flanges, and horn guides. The sinusoidal movement, however, which is pursued by an independent pair of wheels on an axle, will no longer be simple when it forms part of a complete vehicle.

When an engine chassis, from whatever cause, is taking up a position at an angle with the centre line of the track, there are a number of forces acting simultaneously at the tread of the wheels. In considering the effect of these forces, it is important to remember that adhesion between wheel and rail exists not only in the forward direction of movement, but also transversely across the rail head.

First, there is the lateral force, arising possibly from some track irregularity, which causes the engine to depart from its central position on the track. Secondly, there is the traction force, due to the steam acting in the cylinders, which is impelling the engine in a forward direction. Moreover, when the several axles, which are mounted under the same frame, are rigidly connected by coupling-rods to one another, the wheels are compelled to turn at the same angular velocity, in spite of differences in diameter. These may be due not only to variations in the turning of the different tyres, but to the effect of coning of the tyres when the distances of the flanges from the corresponding rails are not equal. As the result of these differences in diameter, further tangential forces are set up at the points of contact of the different wheels on the rail.

These tangential forces, when acting in opposite directions on two wheels of the same axle, will form a couple which will act in two different ways. It will tend to produce torsion in the axle, and it will also tend to pivot the axle about a vertical axis. The arm of this couple is a function of the gauge of the track, and, under equal factors of adhesion (vertical loading and coefficient of friction), the moment of the couple will increase with the width of gauge.

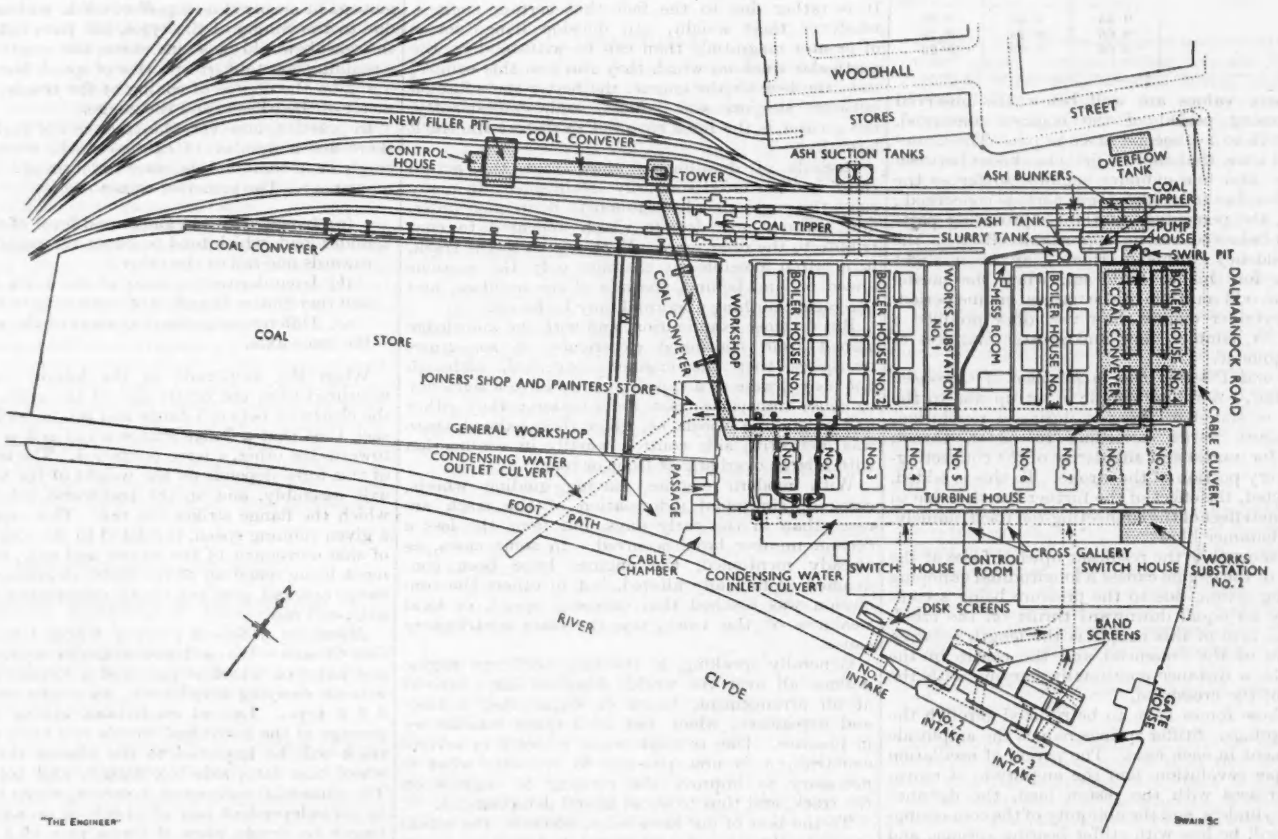
The forces mentioned above, due to traction, side displacements, and inequality in effective wheel diameter, can be resolved, and the direction of the resultant will vary in relation to the longitudinal axis of the engine, according to the relative direction of the original forces. The value of the resultant is dependent on the factor of adhesion. Transverse slipping of the wheel across the rail will take place when the resultant force at the wheel tread exceeds the limit of adhesion.

We are mainly concerned with the transverse component of this resultant force, and it will, for a given value of the resultant, attain a maximum value when the force due to traction acting in a longitudinal direction is low, as, for example, when working with early cut-off or when coasting. This consideration indicates why hunting of locomotives is more often observed on the level and down gradient when tractive effort is small. On the other hand, elastic deformation of all the members, which are subject to transverse reactions between track and engine, has the effect of delaying the rate of increase of the force at the tread of the wheel, and, in consequence, of delaying the instant at which slipping will occur in the direction of the resultant force.

Certain recent theories introduce the idea of elastic deformation of the actual metal of wheel and rail at the point of contact, to explain the possibility of certain

LAY-OUT OF DALMARNOCK POWER STATION

(For description see opposite page)



relative movements of small amplitude of the wheel on the rail, without actual slipping taking place. *Creep or pseudo-glissement*[8] are names given to this conception, and the coefficient of friction under such conditions will be high. This is important, because it allows the possibility of high tangential forces at the point of contact between wheel and rail.

We will now consider what tendencies are produced by these forces on the passage of the engine along a straight track; still assuming that the engine has no guiding wheels, let us consider it deflected obliquely towards the left-hand rail. The left-hand leading wheel then exerts a flange force on that rail, the reaction to which tends to return the engine to its central position; but the tangential forces at the points of contact of all the wheels, other than the left leading wheel, oppose any change of direction of the engine, and tend to make it continue to run obliquely towards the left-hand rail, so long as slipping of the wheel treads towards the right does not occur.

In these circumstances of increasing pressure the left-hand rail deflects outwards and the left-hand leading wheel and its axle also deflect. Since the reaction between wheel and tyre is at rail level, namely, at a point below the centre of gravity of the engine, a rolling movement of the sprung weight is then started towards the left, which has the effect of partially unloading the right-hand side of the engine. Thus, on the one hand, the tangential forces at the points of contact of the remaining wheels increase as the lateral reaction between left-hand leading wheel and rail increases; on the other hand, the vertical load on the right-hand wheels diminishes, as a result of the rolling. The limit of adhesion is thus attained and the right-hand wheels suddenly slip laterally, thus destroying the state of equilibrium between the different forces. The sensitivity to rolling of a particular engine design will affect the degree to which the above sequence of events can occur, but it appears that some degree of unloading of the wheels can take place on the side opposite to that on which a leading flange is striking the rail. The rolling action on a curve is more complicated, and weight may even be relieved from the wheel on which the reaction from the flange is taking place.

Under these conditions there is a flange force on the left-hand leading wheel acting at the leading end of the engine, and all the elastic members under deflection (rails, wheels, and axle) unite in turning the front of the engine towards the right-hand rail. Since, however, the lateral slipping of the right-hand wheels takes place when these wheels are partially unloaded due to rolling, the resistance to transverse displacement is reduced; the engine goes beyond its position of equilibrium, so that after having pivoted about its vertical axis, and at the instant when lateral slipping stops, the engine tends to make with the left-hand rail an angle of return greater than the angle of approach. In continuing its lateral movement and striking the right-hand rail, the same phenomenon is produced at the instant of contact as is outlined above; for the same running speed there is an inherent tendency for the characteristics to be enlarged, as the transverse velocity of impact increases with the angle of incidence of the chassis in relation to the track. This angle also tends to increase at each rebound for the reasons given.

Three different results may follow the foregoing tendency:—

(1) If the track is strong enough laterally not to undergo any measurable deformation, elastic or permanent, if the engine is very rigid in its frame, wheels, and axles, and if the clearances between wheel and rail are tight, the initial deflection at the left-hand rail is reduced. The various members are able to resist the forces arising from the tendency to increased transverse velocity in the second half of the first oscillation. The angle of incidence of the chassis in relation to the track is, therefore, prevented from increasing, and can be retained at a small value, in which the *creepage* effect between wheel and rail, with its very high resistance to lateral slipping, is the predominant factor; in consequence, the oscillations of the engine are self-damped and its passage along the track returns to normal, until the next track irregularity is encountered.

(2) If the track undergoes material elastic deformation in the form of rail tilting or side displacement as a whole, and, in addition, if the frame and wheels of the engine are relatively flexible, the effective clearance between flange and rail is increased by the sum of the resulting deflections. This total amount of side movement affects the angularity of the engine to the track, and therefore governs the transverse velocity with which the leading wheel flange strikes the rail; this velocity, in turn, determines the magnitude of the reactions at the rail, in conjunction with the moment of inertia of the engine about a vertical axis, assumed to pass through its centre of gravity.

These reactions at the rail, commonly known as flange forces, can only attain very high values when the mass carried by the wheel is great, and when the transverse velocity with which the flange is running towards the rail is sufficiently high. These two elements are interdependent; for a given engine and for track of given gauge, the predominating features in the production of high flange forces are clearance between flanges and rail, and elastic deformation of engine parts and of track.

Lateral track flexibility, therefore, tends to induce oscillation to build up, and the engine proceeds along what is in effect a sinusoidally deformed track; so long as this deformation remains within the elastic limit of the track material, no residual deformation can be seen after the passage of the engine. Oscillation will build up if nothing intervenes in the meantime to damp it, or if, in the case of such an intervention, the forces coming into action are not sufficient, in relation to the kinetic energy of the engine.

If the lateral weakness of the track exists only over a short distance, and if the engine can reach a more resistant portion of track, before a serious degree of oscillation has built up, the conditions of (1) predominate. On the other hand, if weakness of the track continues, side displacement, and in consequence flange forces, increase at each successive contact between wheel and rail, and the following case has then to be considered:—

(3) When flange forces increase to such an extent that the spreading of rails (whether by tilting or by bodily displacement on sleepers) is no longer elastic, but becomes permanent, and attain values higher than in (2) above, derailment of the wheels can occur, generally commencing with the leading coupled axle. In these circumstances, the wheels may fall between the rails; alternatively, instead of individual rails becoming displaced, the track as a whole may become distorted if its lateral resistance on the ballast is insufficient. In this case, also, derailment can occur, the track as a whole assuming a sinusoidal form.

If the rail does not fracture, and if the rolling action is out of phase with the nosing of the main frame, the leading coupled wheel, which is exerting high flange pressure, can become unloaded, and the flange may therefore ride on to the rail head. For this to happen the vertical load on the wheel has to be reduced to approximately half the flange pressure for a normal tyre profile; but worn flanges can ride up with a smaller reduction in vertical loading.

The above represents the sequence of events, set out in its simplest terms and taking extreme cases; but it is possible for every degree of intermediate condition also to exist. In practice, track deformations do not always result in derailments, but a very important aspect of the problem is that material disturbances can be set up in the engine by elastic deformation of the track, which is not readily visible after the passage of the engine.

This is because even considerable lateral and vertical deformations of the permanent way, in certain conditions of construction and maintenance, can remain purely elastic, so that, after the passage of the engine, the rails regain their former alignment and position; thus, it might well be disputed whether any track defect was present in order to account for an oscillation experienced on the engine. It seems likely that some degree of spreading of the gauge precedes the sinusoidal disturbance of track as a whole, but if it has been purely elastic no evidence is readily available afterwards.

(To be continued)

[8] "Etude Relative au Contact des Roues sur le Rail" ("A Study of the Contact Between Wheel and Rail"), *Revue Générale des Chemins de Fer*, February, 1935.

New Boiler Plant at Dalmarnock Power Station*

By W. E. YOUNG†

ON the application of the Glasgow Corporation Electricity Department, the Electricity Commissioners, in June, 1935, authorised extensions to the generating station at Dalmarnock, comprising two 50,000-kW turbo-alternators and six boilers, each of the latter to conform to the following :—

Normal evaporation	160,000 lb. per hour
Maximum continuous evaporation...	200,000 lb. per hour
Steam pressure at superheater outlet	625 lb. per square inch
Steam temperature at superheater outlet	850 deg. Fah.
Temperature of feed water at economiser inlet	320 deg. Fah.
Temperature of the chimney gases at normal load not to exceed	250 deg. Fah.
Fuel, Lanarkshire coal, having a gross calorific value of	10,500 B.Th.U. per lb.
Ash content, about	10 per cent.
Moisture content, about	14 per cent.

The steam temperature of 850 deg. Fah. was to be obtained at an evaporation of 200,000 lb. per hour, and the variation in temperature between that load and 100,000 lb. per hour was not to exceed 25 deg. Fah.

The boiler plant existing in this station then operated at a working pressure of 270 lb. per square inch with steam superheated to 700 deg. Fah. The increase in pressure and temperature for the new plant was adopted to provide a high thermal efficiency, though this necessitated the new plant forming a separate section with no steam pipe connections from the existing boilers. The capacity of the new boilers was fixed so that five units would provide steam for the two new alternators, leaving one boiler as a standby.

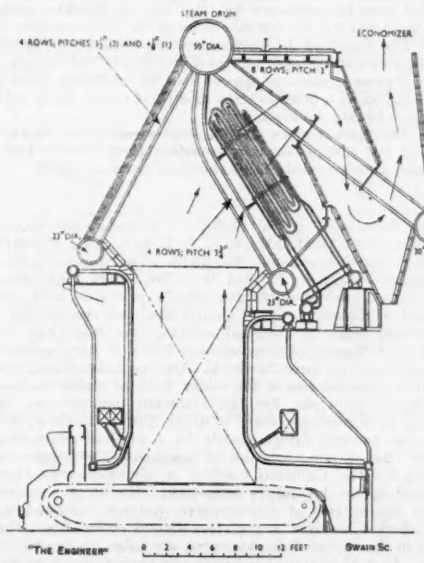


FIG. 3—*Cross Section Through Boiler*

Site Conditions.—The engraving on the opposite page shows the position of the new plant in relation to the existing buildings, and the general lay-out of Dalmarnock power station. The new boiler-house, No. 4, had to be erected on the vacant space between the existing No. 3 boiler-house on the west, the Dalmarnock Road on the east, coal sidings to the north, and the turbine house to the south, the space available being 150ft. 6in. long by 88ft. 4in. wide. The new boilers were thus to have an evaporative capacity equivalent to 89 lb. of steam per square foot of ground area, as compared with 33 lb. for the existing boiler-houses. Further restrictions were :—A condensing water culvert at the south end, a cable tunnel below the pavement level of Dalmarnock Road, and at the north end a coal hoist for No. 3 boiler-house, which could not be removed. Owing to the east wall lining up with the pavement, and to there being dwelling-houses on the opposite side of Dalmarnock Road, the height of the new boiler-house was limited by building regulations.

The difficult nature of the soil necessitated a raft form of foundation with equal weight distribution, and as experience with previous buildings on the site indicated that some settlement would take place, the attachments of the new building to adjacent buildings were made flexible.

DESCRIPTION

Foundations and Loading.—As muddy clay and silty sand extend to a depth of approximately 80ft. below ground level, piles could not be used, and a reinforced raft type of foundation was adopted, the average load on the ground not exceeding 1½ tons per square foot. Records of the settlement of the raft relative to the adjacent buildings have been kept and indicate that the new structure at the south end has permanently sunk by 1¾in., and at the north end by 2¼in., though there has been no further settlement over a period of some months. The raft is of cellular form, 11ft. deep, to reduce the dead weight, and at the same time to provide the necessary stiffness in view of the heavy concentration of loads and the wide spacing of the principal stanchions. The maximum total load on any stanchion base is 718 tons and the total load carried by the raft amounts to 13,340 tons. The raft has a bottom slab 18in. thick and an 8in. thick top slab, forming the basement floor of the boiler-house. The transverse and longitudinal ribs vary in thickness from 18in. to 30in. The top surface of the raft is recessed to receive the stanchion bases, which are designed for a maximum pressure of 30 tons per square foot. The raft design is complicated by four lines of ash and riddlings, troughs running lengthways, and heavy steel reinforcement was necessary. To clear the cable trench on the Dalmarnock Road frontage strongly reinforced projections are corbelled out to form cantilevers from the main raft to carry the building stanchions on that side. A view of the foundations under construction is reproduced in Fig. 1.

Building.—The building (Fig. 2) is steel-framed with brick panel walls, the total of the vertical loads carried by the building amounting to about 7000 tons. The main columns are spaced at about 15ft. centres and are so arranged that their horizontal forces are transmitted through bracing to the coal bunker columns at the firing aisle. The latter are diagonally braced to leave a clear passage and are composed of two 16in. by 6in. by 50 lb. rolled joists with 22in. by 2in. thick plates riveted to the flanges. At the turbine house end the new boiler-house is cantilevered over the condensing water culvert for a length of about 16ft. by utilising the two main longitudinal bunker girders as cantilevers and suspending the lower floors from them, and by introducing, above the foundation level, lattice girders at the side of the house with a corner stanchion above.

The six bunkers, each of about 200 tons capacity, are of special interest, as they are among the first in this country of such dimensions to be of welded construction. The main longitudinal bunker girders, supporting a vertical load of about 400 tons, are made up of a top boom of 20in. by 2in. slab section welded to a ½in. thick web plate laterally supported by stiffeners, and a bottom boom which is of unusual design, as it incorporates a horizontal girder of bow shape. The horizontal girder transmits all lateral thrust from the contents of the bunker to the main braced columns. The hopper portions of the bunkers were welded together in complete units before lifting into place and are bolted to the bottom flanges of the main girders. The method of seating the girders on the column caps is by half checking the cross girders on the top and half checking the longitudinal girders on the bottom, keeping the web plate of the longitudinal girders clear of the inner flange of the main columns, so simplifying the junction of the hoppers and ensuring concentric loading on the columns. The bunkers are lined with reinforced concrete, 2in. thick.

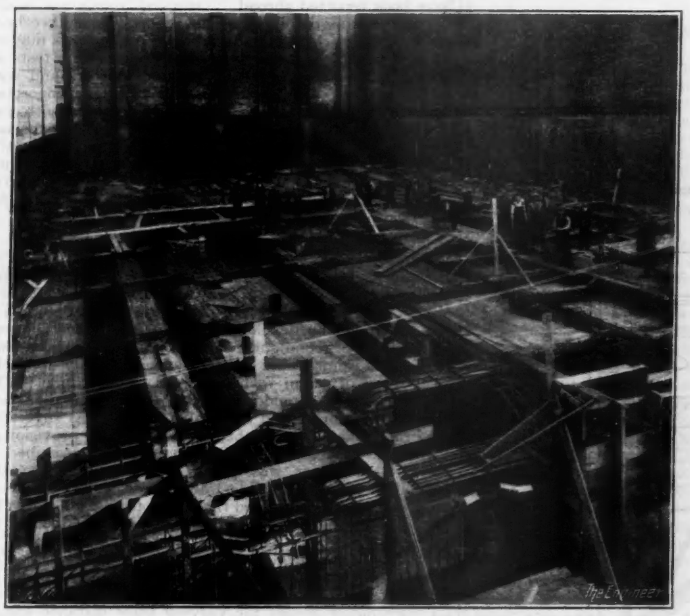


FIG. 1—*Foundations under Construction*

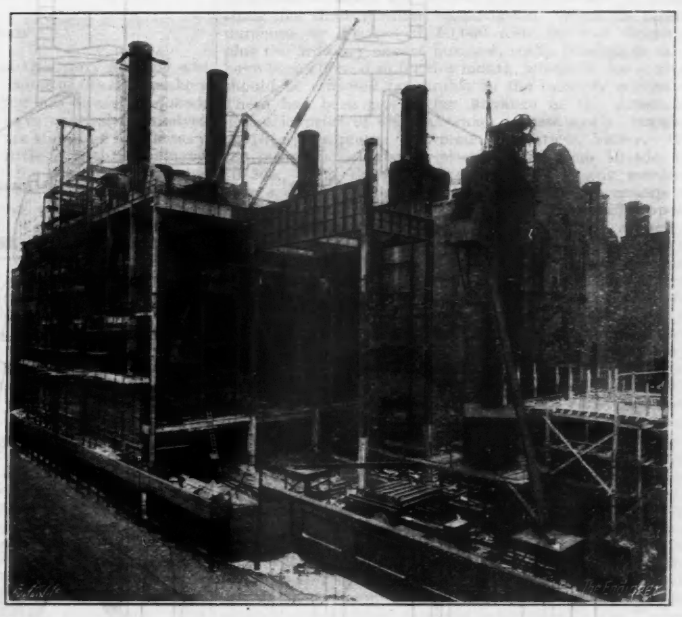


FIG. 2—*Boiler-House under Construction*

Boilers.—The boilers are of the Yarrow water-tube land type, each having one steam and three water drums with three separate banks of tubes. The total generating heating surface of each boiler unit is 15,630 square feet, of which 3240 square feet is in the front bank, 3590 square feet in the bank between the furnace and the superheater, and 8800 square feet in the rear bank, which the gases traverse three times after passing through the superheater. The part of the boiler tube surface subject to direct radiation from the furnace is 4848 square feet, or, taken as a wall surface, 1046 square feet. Fig. 3 shows a cross section through the boiler.

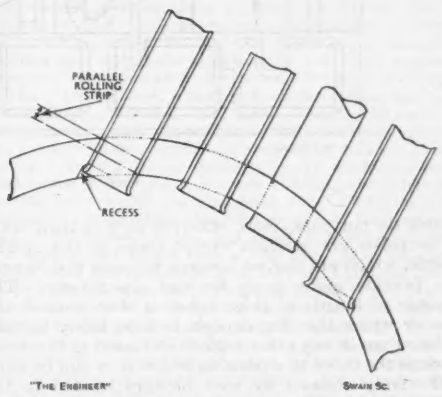


FIG. 4—*Section of Drum Shell*

The tubes in the front bank and in the bank between the furnace and superheater are 2½in. external diameter, those in the two rows in each bank nearest the furnace being 6 S.W.G. thick and in the other rows 8 S.W.G. The tubes in the rear bank are 2in. external diameter and 8 S.W.G. thick.

The tubes in each separate bank enter the drums parallel to one another so that most of them are not radial to the drum centre, this being the established practice in the design of Yarrow boilers both for land and marine installations. In all cases where the

* Paper read before Steam Group of the Institution of Mechanical Engineers, Manchester, March 23rd.

† Director, Yarrow and Co., Ltd.

tubes enter the drum shells at some angle between the radial and tangential, the thickness of the drum is such that there is a minimum parallel rolling strip of about $\frac{5}{8}$in., which compares with $\frac{1}{2}$in. minimum required by the Board of Trade and Lloyd's. In the case of the steam drum and the rear water drum the thickness of the shell is that required for strength considerations and the parallel rolling strip is in excess of the minimum referred to above; but in the other water drums which are of smaller diameter the shell thickness required to give the minimum width of rolling strip is in excess of that required for strength. Fig. 4 illustrates the section of one of the drum shells in way of the tube holes and indicates the parallel rolling strip. In the extreme case where the angle of the tube hole to the radial line is greatest the diameter of the hole on the inside of the drum is increased for part of its depth to form a recess as shown in Fig. 4.

The spacing of the tubes is diagonal, except in the front bank, where the front row tubes are placed to block the lanes through the other three rows. This is done to make this bank, through which the gases do not pass, more effective as a radiant wall. The tubes are straight except those in the middle bank, which are curved inwards towards the furnace to provide more space for the superheater. The centre of length of these tubes is that part of the boiler where the slag deposit is more likely to take place than in any other region, and curving this bank brings the tubes to a position where they can be more effectively cleaned by soot blowers located in the front bank. The longest exposed length of $2\frac{1}{4}$in. external diameter tube is 19ft., equivalent to about 100 diameters, while the longest exposed length of 2in. diameter tube is 21ft. $8\frac{5}{8}$in., or about 130 diameters.

The steam drum is a seamless forging, of steel of 34–38 tons per square inch ultimate tensile strength, elongation 23–19 per cent. on British standard test piece C, 50in. internal diameter, $2\frac{3}{4}$in. thick, with ends closed in by the forging process to $4\frac{1}{2}$in. thickness at the 16in. by 12in. centrally placed manhole. The water drums also are seamless forged shells, of steel of 28–32 tons ultimate tensile strength, elongation 29–25 per cent. on British standard test piece C, with separate ends secured by riveting. The rear water drum is 30in. internal diameter with a 2in. thick shell and ends, of steel of 26–30 tons ultimate tensile strength, elongation 23–19 per cent. on British standard test piece B, $1\frac{1}{4}$in. thick, pressed to an internal radius of 24in. The smaller water drums are 23in. internal diameter with shells $1\frac{3}{8}$in. thick, the ends being flat forgings, $2\frac{1}{2}$in. thick, of steel of 28–32 tons ultimate tensile strength, elongation 29–25 per cent. on British standard test piece C.

All steel used in the manufacture of the drums was made by the Siemens-Martin open-hearth acid process and the forgings are to British Standard Specification No. 29—1909.

The steam drum is 37ft. 6in. long overall and weighs 27 tons, each end resting in a chair on a steel structure, one chair fitted with rollers for longitudinal expansion. The water drums are partially supported in a line parallel to the tube banks to allow the tubes to expand freely.

The total weight of the water drums, tubes, and attachments, including the weight of the steam drum and its contents, making allowance for the reactions of the water drum supports, is 150 tons, and this weight is supported entirely by the steam drum. The thickness of the drum was determined so that the circumferential stress did not exceed the permissible stress of the material at the working metal temperature. Calculations were made of the longitudinal stresses due to (*a*) the internal steam pressure acting on the drum ends, (*b*) bending caused by the excentricity of this end pressure, and (*c*) bending caused by the externally applied loads, and it was found that these stresses were considerably less than the allowable stress of the material. Although part of the bending moment is withstood by the water drums, this was neglected, the whole of the bending moment being taken as applying to the steam drum alone.

The internal fittings of the boiler call for no special comment. The steam passes through purifiers and the feed water is distributed through perforated internal pipes discharging upwards through small holes. Fig. 5 is a cross section showing clearly the design.

(To be continued)

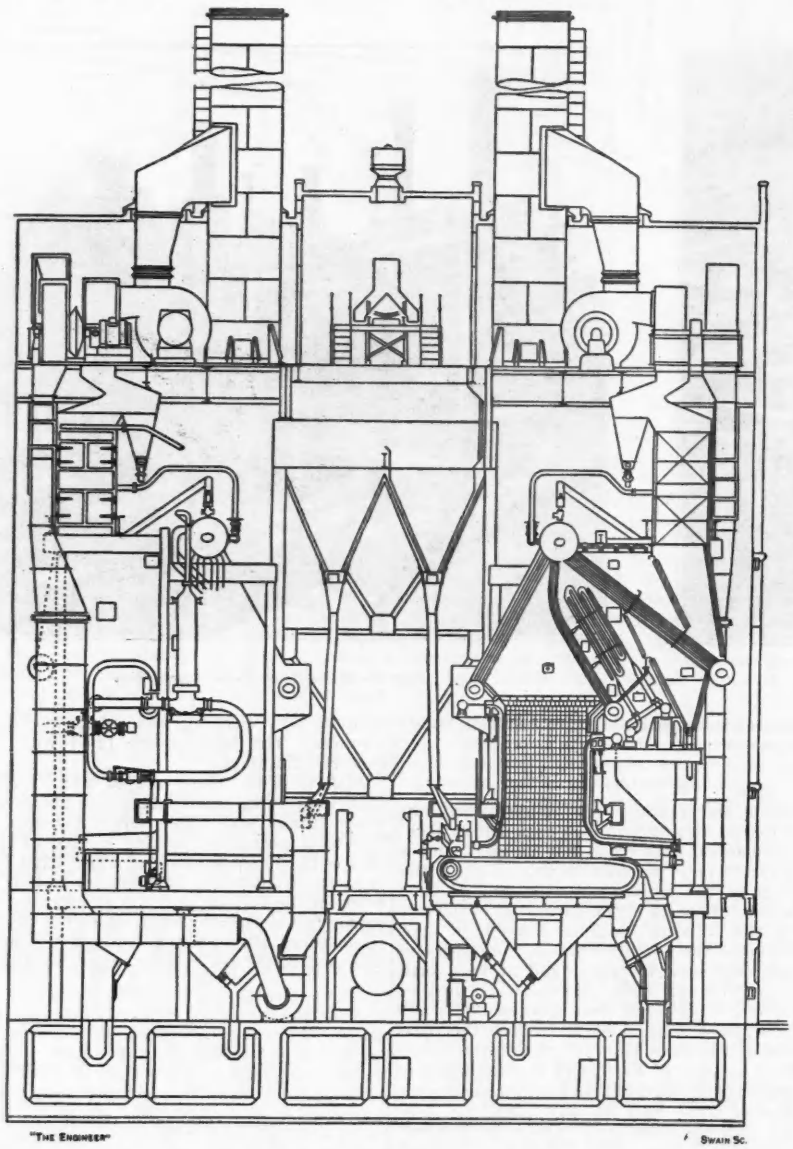


FIG. 5—*Cross Section Through Boiler-house*

LAUNCH OF THE "DUKE OF YORK."—It is officially announced that the Queen will launch the new 35,000-ton battleship, "Duke of York," at Clydebank on September 16th. The new vessel is one of five new £8,000,000 battleships, and is being built by John Brown and Co., Ltd., of Clydebank.

Technical Reports

The Solubility of Cements. By F. M. Lea, D.Sc., F.I.C. Building Research Technical Paper No. 26.—The Joint Sub-Committee on Special Cements of the Institution of Civil Engineers and the British Committee on Large Dams have had under consideration the properties desirable in cements to be used for mass concrete subjected to water pressure on one side. Arrangements were made for an investigation to be carried out at the Building Research Station on methods for comparing the relative resistance of cements to leaching when soft waters percolate through concrete. The solubility of cement is recognised as one factor to be considered in the deterioration of concrete dams exposed to the action of pure and slightly acid natural waters. It is commonly observed that in dams which have become leaky a deposit of lime is found on the downstream face. While the primary cause of deterioration is the permeability of the concrete, the extraction of the lime from the cement and its removal in solution must eventually increase the rate of decay. When the water impounded behind a dam is hard, the amount of leaching is not usually serious, and, indeed, lime may even be deposited from the water rather than removed by it in solution. With soft waters, however, such as are common in many mountain areas, solution of the lime may become a serious factor, and many instances of decay of this type have been reported abroad.

The methods described in the report which have been used for comparing the solubilities of set cements may be divided into three main classes:—(1) Extraction tests on set cement; (2) percolation tests on mortars and concretes; (3) surface solution tests on mortars and concretes. Tests with these various methods were made with two normal Portland cements, two Portland blast-furnace cements, and one pozzuolanic cement, from which it is concluded that the extraction tests on ground set cements, developed originally in Sweden, afford a simple measure of their relative susceptibilities to attack adequate for practical purposes.

Further Development of a High-speed Wind Tunnel of Rectangular Cross Section. By A. Bailey, M.Sc., A.M. Inst. C.E., and S. A. Wood, M.Sc. Air Ministry Reports and Memoranda No. 1853.—In a previous paper a description was given of the development of a high-speed induced wind tunnel of rectangular cross section, and it was shown that such a tunnel could be operated successfully up to the local speed of sound with no model in the tunnel. The introduction of a model caused a substantial reduction in the maximum speed attainable, and it was suggested that this difficulty might be overcome by the provision of adjustable flexible walls. The investigation described in the present paper was undertaken to determine the feasibility of using flexible walls. During the course of the work, it was considered that the construction would be considerably simplified if two of the ejector slots could be suppressed, and this feature was also investigated.

Range of Investigation.—A wind tunnel was constructed having a working portion 5in. by 2in. in cross section, the 2in. sides being made of flexible spring steel strip mounted on micrometer screws for varying their distance apart. Experiments were made on the reduction of interference between tunnel and model, the control of speed by a downstream contraction, and the length of working section necessary for satisfactory upstream and downstream conditions. Determinations were also made of the maximum working speeds obtainable with models of different sizes, with angles of incidence of zero and 10 deg. For the tests on the suppression of the ejector slots, the 6in. by 3in. tunnel, constructed for the earlier tests, was used. The slots on the 3in. sides were first completely closed and subsequently the width of the slots on the 6in. side was modified.

Conclusions.—(1) Satisfactory speed distribution and control can be obtained by the use of flexible walls, 0·015in. thick, on the shorter sides of the cross section.

(2) The length of the working section should be approximately twice the greater lateral dimension of the tunnel.

(3) Higher maximum speeds can be obtained with a given model in a flexible than in a rigid tunnel both with zero and 10 deg. incidence.

(4) The ejector slots on the shorter sides can be suppressed, but this results in a considerable increase in high-pressure air consumption for the same working speed.

The Principles of the Galerkin Method. By W. J. Duncan, D.Sc., A.M.I. Mech. E., F.R.Ae.S. Air Ministry Reports and Memoranda No. 1848.—The present report is supplementary to R. and M. 1798. Part I discusses the connection between Rayleigh's principle and the method of Galerkin. It is shown that the two methods necessarily lead to identical results, provided that the number of degrees of freedom and forms of displacement assumed are the same for both. On the other hand, the Galerkin method has a far wider field of validity than Rayleigh's principle, for the Galerkin method can be applied to non-conservative systems, forced motions, &c. It is also proved independently by a method depending on the idea of the variation of mass that the frequency yielded by the Galerkin method is identical with that obtained from the energy equation. Hence, the errors in the frequencies of conservative systems obtained by the Galerkin method are of the second order when the errors in the mode of displacement are taken to be of first order. Part II is concerned with the choice of the multipliers for use in the Galerkin process, and simple rules are given by which the multipliers can be obtained by inspection in all ordinary cases. A number of varied examples of statical and dynamical problems are given by way of illustration. One of them is the problem of the oscillation of a cantilever with elastic angular yield at the root. This is easily solved exactly when the beam is uniform, but an approximate solution of any required degree of accuracy can readily be found by the Galerkin method when the beam is not uniform. In Part III suggestions are made regarding practical applications of the Galerkin method and Rayleigh's principle, and the case of the fluxural oscillation of a fuselage is considered in some detail. The influence of tailplane flexibility on the frequency is discussed in the appendix.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Iron and Steel Exports

The exports of iron and steel and manufactures thereof in June, according to the Board of Trade Returns, fell slightly to 162,289 tons, valued at £3,238,642, compared with 168,513 tons, valued at £3,396,336, in May. The following are details of the principal exports :—

	1938. Total. Tons.	1939. May. Tons.	1939. June. Tons.
Pig iron : Total	94,012	11,536	6,283
Forge and foundry	44,375	7,127	4,156
Acid	25,690	4,009	1,906
Basic	23,947	400	221
Ferro-alloys	6,787	255	391
Sheet bars, bright steel bars, and wire rods	22,162	1,264	1,452
Bars and rods, other kinds	102,074	6,842	6,796
Angles, shapes, and sections	67,319	5,745	5,995
Girders, beams, joists, &c.	33,525	1,628	2,435
Hoop and strip	37,408	4,198	3,311
Plates and sheets, ¼in. and over : Total	131,052	12,321	17,006
South Africa	7,551	546	2,373
British India	16,926	1,127	1,596
Australia	7,551	122	372
Canada	1,966	240	819
Other British countries	30,085	1,499	2,620
Denmark	38,611	3,611	2,856
Holland	10,633	2,301	3,776
Plates and sheets under ¼in.: Total	63,516	5,513	9,134
British India	4,550	259	300
Australia	16,398	307	308
Canada	5,097	267	854
Mexico	1,880	—	—
Argentine Republic	13,113	1,136	4,965
Galvanised sheets	147,332	14,739	13,785
Tinned plates	319,403	31,977	28,862
Tubes, pipes, and fittings : Cast :			
Up to 6in. diameter	48,985	5,559	5,155
Over 6in. diameter	42,946	3,958	5,646
Wrought	220,011	18,531	17,214
Railway material :			
Steel rails, new	105,999	8,081	7,177
Sleepers, fish-plates, and sole-plates	25,618	1,581	1,330
Total all iron and steel	1,917,639	168,513	162,289

Iron and Steel Imports

The following figures, taken from the Board of Trade Returns for June, show that imports of iron and steel and manufactures thereof increased to 199,933 tons from 142,612 tons in the previous month, and the value to £1,821,141 from £1,420,218. Only the figures for the most important countries are given :—

	1938. Total. Tons.	1939. May. Tons.	1939. June. Tons.
Pig iron : Total	395,151	35,772	25,052
British India	155,653	27,489	16,763
Foreign countries	231,365	7,176	8,289
Ferro-alloys	47,606	9,974	6,758
Blooms, billets, and slabs : Total	314,989	28,785	37,753
British countries	59,462	10,036	12,494
Sweden	1,104	47	87
Germany	27,569	—	1,781
Belgium	55,417	6,329	5,483
France	101,188	9,317	15,949
Other foreign countries	70,249	3,056	1,959
Sheet bars	33,606	17,146	53,788
Wire rods	60,021	4,713	10,536
Other bars and rods	102,919	13,312	13,285
Angles, shapes, and sections	44,958	4,827	5,495
Girders, beams, joists, &c.: Total	60,134	6,129	8,486
Belgium	5,493	1,616	1,772
France	38,191	2,112	3,974
Other foreign countries	14,534	1,451	2,740
Plates and sheets (not coated)	68,009	4,599	16,232
Wrought tubes	22,880	2,499	2,508
Railway material	20,458	1,089	1,307
Bolts, nuts, and metal screws	7,109	487	518
Total from countries :			
British India	155,664	27,489	16,763
Canada	117,051	15,883	21,271
Germany	94,685	5,850	9,926
Sweden	89,804	13,605	12,985
Holland	32,583	602	433
Belgium	273,586	32,024	59,380
Luxemburg	58,570	14,099	16,090
France	257,304	19,978	50,457
Czechoslovakia	12,367	369	286
United States	20,671	3,766	6,399
Total imports, iron and steel	1,340,735	142,612	199,933

The Pig Iron Market

There is still no news regarding the future prices of foundry pig iron. Consumers, naturally, are hoping that there will be some reduction, especially as Scottish foundry iron was recently reduced 5s. a ton, but the English makers give no indication that they are even contemplating any change. The production of foundry iron on the North-East Coast is very limited, and makers prefer not to make any substantial increase in the current output. The former substantial trade in Cleveland foundry with consumers North of the Tweed is now a thing of the past, while export business is virtually at a standstill. Hematite is moving more briskly now that prices are cheaper, but makers still have quite substantial stocks upon which they can draw. Consumers in other areas, too, are again in the market for Cleveland hematite, while merchants have been able to maintain a steady, though only small, business in special qualities with the Continent. There are indications, however, that the consumption is likely to make a steady improvement. In the Midlands it is reported that makers of light castings have again come on the market for pig iron, as they are anxious to add to their reserves in case of emergency. In consequence, some sales of high-phosphoric pig iron have been made, and occasionally these contracts have been made for delivery over the next few months, which is a change from the past hand-to-mouth scale of consumption. Makers of low phosphoric pig iron are very heavily sold, while increased activity has been noticed in hematite. The hematite section is one of the brightest features, as orders which had been accumulating during the period between the announcement of the reduction and July 1st when the new price came into force, have now been released. The heavy foundries which use hematite are also benefiting substantially from Government orders, and there is every indication that this demand will be maintained. Basic pig iron is being produced in large quantities, but the output is still insufficient fully to meet consumers' demands. Indian pig iron is freely imported, while an entirely fresh feature is the importation of pig iron from Australia.

The Midlands and South Wales

Last week's Birmingham Quarterly Meeting was without any special significance. Some of the steel makers have no material to offer as they are heavily booked, while in other cases consumers have covered themselves sufficiently far ahead. As prices are stabilised for delivery to the end of October, there is little initiative displayed towards new business. Pressure for deliveries continues strong, and the structural engineers in particular, being mostly employed on Government work, are especially urgent in their demands. The sheet makers, too, are fully occupied for many months to come, and the production of bright steel bars and of cold rolled steel strip is on a high level. Business in finished iron is still on the quiet side, although there has been a tendency for some steel consumers to revert to wrought iron in cases where its substitution is practicable. In Wales also active conditions prevail, production is heavy, and the re-rollers are fully booked. Sheet bars are in strong request, and the local output is being augmented by increased arrivals from the Continent. The first parcel of pig iron from Australia has arrived in South Wales, and it is expected that some of the Australian semis ordered will come to this district. There is a continued good demand for heavy rolled steel, specifications from structural engineers being especially heavy. Soft steel billets for re-rollers, as well as sheet and tin-plate bars, are in keen request, and although over 95 per cent. of the steel furnaces are in operation the output of sheet bars is insufficient to satisfy the consumption. Sheets and tin-plates are the most active section of the South Wales trade. Air-raid precaution demands are unprecedented, and vast quantities of black and galvanised sheets are being turned out. The demand is such that the mills are likely to be fully employed for many months, and both home commercial users and would-be buyers overseas have to accept far-forward deliveries. Tin-plates have been an active market, and home consumptive demand has made an appreciable advance. This can in part be attributed to the recent advice of the Government to householders to begin laying in small food reserves, of which the majority would be tinned. Home consumers of tin-plates have been placing orders for delivery as far ahead as the end of the first quarter of next year. Export business has continued on a steady scale.

Current Business

The Barrow Hæmatite Steel Co., Ltd., announces that an agreement has been reached with Colvilles, Ltd., Glasgow, by which, as part of an exchange of products manufactured by each company, Barrow Hæmatite will cease to operate its heavy and merchant mills for ten years as from January 1st next. The Barrow company will retain and continue to operate its mines, blast furnaces, and hoop and bar mills. The Turkish Railways have placed orders with the Metropolitan Cammell Carriage and Wagon Company, Ltd., for 300 pairs of steel hopper wagons for iron ore conveyance. Greece has ordered boilers and machinery for two destroyers from Yarrow and Co., Ltd., Scotstoun. A contract for light steel aeroplane hangars for Bristol has been awarded to P. and W. MacLellan, Ltd., Glasgow. The General Electric Company, Ltd., has obtained a contract for plant and switch gear for the London and North-Eastern Railway suburban electrification work. Extensions are being made to the Bold Ironworks, St. Helens Junction, Lancs, of W. Neill and Son (St. Helens), Ltd., engineers. Munro and Miller, Ltd., are enlarging their premises at Moorepark Tube Works, Edmiston Drive, Govan. The Workington Iron and Steel Company, Ltd., has sold 80,379 acres of land at Westfield Farm to the Workington Corporation for the sum of £10,000 for use as a housing estate. The North British Locomotive Company, Ltd., Glasgow, has secured a contract for fifteen locomotives and tenders for the North-Western Railway of India. The foundry department of the London and North-Eastern Railway at Cowlairs Works, Springburn, Glasgow, has been closed down indefinitely, owing to lack of business. It is proposed to establish a new works at Newport, Mon, on a site adjacent to the Whitehead Iron and Steel Company, Ltd., who are responsible for the development. The works would cover between 6 and 8 acres, and would give employment to about 400 operatives. The Whitehead Company will supply 300 tons of material per week. The South African Railways and Harbours Administration has placed orders for 66,000 tons of rails. Of these, British firms will supply 37,000 tons and two Canadian firms 29,000 tons. The following British works are concerned :—Guest, Keen, Baldwins (£77,000); Dorman, Long and Co., Ltd. (£71,000); Cargo Fleet Iron Company, Ltd. (£34,000); Lancashire Steel Corporation, Ltd. (£34,500); Barrow Hæmatite Steel Company, Ltd. (£28,000); Skinningrove Iron Company, Ltd. (£19,400); Steel Company of Scotland (£17,000); Colvilles, Ltd. (£25,000); United Steel Companies (£10,700). The Department of Overseas Trade announces that the following contracts are open for tender :—Argentine State Railways Administration : Quantities of switches for rails and manganese steel mono-block frogs (Buenos Aires, August 28th). Egyptian State Domains Administration : Number of transportable and centrifugal irrigation pumps with necessary suction and delivery pipes (Alexandria, August 21st).

Copper and Tin

During the past week business in copper on both sides of the Atlantic has quietened down. In America, hectic buying by consumers was witnessed during the first week or so of July, and by the middle of this week domestic sales of electro there were estimated to amount to about 160,000 short tons, representing something like three months' consumption. With the recent purchase by France of 50,000 tons for war reserves, plus the ordinary export business, really formidable sales have been effected so far this month, which, in due course, should be reflected favourably in the monthly statistics. There has been no further advance in the American domestic price of electro, which, consequently, remains at 10¼c. per pound delivered Connecticut Valley. On the international market electro eased from 10·45c. to 10·30c., c.i.f. Europe. There has, in recent months, been a distinct improvement in the rate of operations at American consuming factories, and the brass mills appear now to be working at about 70 per cent. of capacity. On the London standard market speculative activity is restricted, and although in the ordinary course of events the reverse might have been expected, the explanation is probably that in view of international politics would-be speculators are chary of committing themselves too deeply. However, it is probable that buyers at the present time would run little risk, as, in view of the inflationary tendencies all over the world, it is to be expected that sooner or later most commodity prices—at least, when expressed in sterling—will go higher. . . . The standard tin market in London remains "pegged" with cash absolutely steady at £230 sellers. Rarely has the market been in such a colourless and drab condition as nowadays. Inevitably speculative interest is at a minimum, since with prices controlled there is no incentive for anybody to go either on the "bear" or "bull" side. At the same time, many consumers in the United States are holding aloof in the expectation that sooner or later the Buffer Pool will be prepared to sell at less than £230 cash. Whether this view will prove correct or not it is difficult to say at the moment. It seems certain that the discontent now evident amongst consumers in the United States is not going to have a good influence in the long run on the world consumption of tin. It has to be remembered that in addition to the present full price, consumers have to pay large premiums in order to obtain special brands. Advices from Bolivia indicate that the tin miners there do not see eye to eye with the Government, which has decided to take over all the foreign exchange obtained through sales of tin ore. The mining interests are protesting that they are threatened with higher production costs which may make it difficult for them to operate profitably. The final outcome of this squabble may have an important bearing upon the future policy of international restriction.

Lead and Spelter

Steady conditions have prevailed on the lead market during the past week. Despite the setback in house-building, consumption in this country is well maintained, no doubt because rearmament business is acting as a compensating factor. Producers have recently claimed that they have succeeded in curtailing supplies to some extent, and there is now some statistical evidence of this. In any case, although fresh arrivals of lead are no unduly restricted, the metal coming forward is being readily taken up, and as a result the undertone of the market looks cheerful. Nevertheless, current prices cannot return a lot of profit to many producers, and there is no doubt that a number of them would like to see the price higher, say, at least £16. Statistics just published indicate that the consumption of lead outside the United States, Russia, and Japan is well maintained—in fact, rather higher than a year ago. In the United States, also, the consumption of lead has improved compared with last year, and as regards Russia it seems safe to assume that, in accordance with the general industrial policy, the quantities of lead used are expanding. Japan comes into the market from time to time, and is undoubtedly needing large tonnages of lead in connection with the China campaign; consequently, her consumption is quite heavy despite the measures taken to discourage commercial consumption there. . . . The spelter market is in a dull state at the moment, there being a number of adverse factors tending to hold prices in check. These include a superabundance of ultra-cheap zinc concentrates, lack of any real progress towards the reconstitution of the proposed International Zinc Cartel, and the probability that Germany, owing to the intensive development of her spelter industry, will this year (particularly having regard to her shortage of foreign currency) keep more aloof from the international market as a buyer than in previous years. On the other hand, the continued heavy consumption of spelter in the United Kingdom in connection with the manufacture of air raid shelters is a supporting factor. The shelter scheme is expected to result in the additional use of some 35,000 tons of zinc in this country. Another favourable development is the fact that it is now possible to sell foreign spelter more readily on the American market than hitherto, thanks to the recent reduction in the import duty there.

Current Prices for Metals and Fuels

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from Associated British Steelmakers. †Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-. (*D/d Teesside Area.*)

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Hematite Mixed Nos.	5 15 0	—
„ No. 1	5 15 6	5 15 0
Cleveland—		
No. 1	5 2 0	5 2 6
No. 3 G.M.B.	4 19 0	5 0 0
No. 4 Foundry	4 18 0	—
Basic	4 12 6	—
MIDLANDS—		
Staffs— (*Delivered to Black Country Station.*)		
North Staffs Foundry	5 1 0	—
„ „ Forge	4 18 0 to £5 0 0	—
Basic	4 12 6	—
Northampton—		
Foundry No. 3	4 18 6	—
Forge	4 15 6 to £4 17 6	—
Derbyshire—		
No. 3 Foundry	5 1 0	—
Forge	4 18 0 to £5 0 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	5 15 6	—
No. 1 Foundry, ditto	5 3 0	—
No. 3 Foundry, ditto	5 0 6	—
Basic, d/d	4 12 6	—
N.W. COAST—	5 15 6 d/d Glasgow	
Hematite Mixed Nos.	6 1 0 „ Sheffield	
	6 7 0 „ Birmingham	

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
LANCS AND YORKS—		
Crown Bars	12 5 0	—
Best Bars	12 15 0	—
MIDLANDS—		
Crown Bars	12 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	10 17 6	—
No. 4 Quality	11 7 6	—
SCOTLAND—		
Crown Bars	12 5 0	12 5 0
Best	12 15 0	12 15 0
N.E. COAST—		
Crown Bars	12 5 0	12 5 0
Best Bars	12 15 0	12 15 0
Double Best Bars	13 5 0	13 5 0
NORTHERN IRELAND AND FREE STATE—		
Crown Bars, f.o.q.	12 17 6	—

STEEL.

	*Home. £ s. d.	†Export. £ s. d.
LONDON AND THE SOUTH—		
Angles	10 10 6	10 0 0
Tees	11 10 6	11 0 0
Joists	10 10 6	10 0 0
Channels	10 15 6	10 5 0
Rounds, 3in. and up	11 10 6	11 0 0
„ under 3in.	11 17 6‡	11 0 0
Flats, under 5in.	11 17 6‡	11 0 0
Plates, ¼in. (basis)	10 15 6	10 2 6
„ ⅜in.	11 0 6	10 7 6
„ ½in.	11 5 6	10 12 6
„ ⅝in.	11 10 6	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 13 0	11 12 6
NORTH-EAST COAST—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ ⅜in.	10 15 6	10 7 6
„ ½in.	11 0 6	10 12 6
„ ⅝in.	11 5 6	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 8 0	11 12 6
MIDLANDS, AND LEEDS AND DISTRICT—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 16 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ ⅜in.	10 18 0	10 7 6
„ ½in.	11 3 0	10 12 6
„ ⅝in.	11 8 0	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 10 6	11 12 6
GLASGOW AND DISTRICT—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ ⅜in.	10 15 6	10 7 6
„ ½in.	11 0 6	10 12 6
„ ⅝in.	11 5 6	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 8 0	11 12 6
SOUTH WALES AREA—		
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ ⅜in.	10 18 0	10 7 6
„ ½in.	11 3 0	10 12 6
„ ⅝in.	11 8 0	10 17 6
Un. ⅝in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6

IRELAND—F.O.Q.—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	10 13 0	10 15 6
Tees	11 13 0	11 15 6
Joists	10 13 0	10 15 6
Channels	10 18 0	11 0 6
Rounds, 3in. and up	11 13 0	11 15 6
„ under 3in.	12 0 0‡	12 2 6
Plates, ¼in. (basis)	10 15 6	10 18 0
„ ⅜in.	11 0 6	11 3 0
„ ½in.	10 5 6	11 8 0
„ ⅝in.	11 12 6	12 10 0
Un. ⅝in. to ½in. incl.	11 12 6	11 12 6

‡ *Rounds and Flats tested quality; untested, 3s. less.*

OTHER STEEL MATERIALS

Sheets.	Home. £ s. d.	Export, f.o.b. £ s. d.
11-G. and 12-G., d/d	13 15 0	11-G. to 14-G. 11 5 0
13-G., d/d	14 2 6	15-G. to 16-G. 11 15 0
14-G. to 20-G., d/d	14 10 0	17-G. to 18-G. 12 0 0
21-G. to 24-G., d/d	14 15 0	19-G. to 20-G. 12 5 0
25-G. and 26-G., d/d	15 10 0	21-G. to 22-G. 12 17 6

South Africa, Rhodesia, Nyasaland, £14; Canada, £14 12s. 6d., f.o.b. basis. Irish Free State, £14 15s., f.o.q., 4-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10-cwt., £2 per ton extra.

Galvanised Corrugated sheets, basis 24-G.—

Home.	£ s. d.
4-ton lots and up	17 5 0
2-ton to 4-ton lots	17 12 6
2 tons	18 17 6

Export: India, £17 15s. c.i.f.; Irish Free State, £17 5s., f.o.q.; General, £15 15s., f.o.b., 24-G. basis.

TIN-PLATES—
20 by 14 basis, f.o.t., Bristol Channel Ports, 20s. 4½d.
Tin-plate Bars, d/d Welsh Works, £7 5s.

BILLETS—100-ton lots and over, 35 to 100 tons, 5s. extra; less than 35 tons, 10s. extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 7 6
„ „ „ tested	7 12 6
Basic (0·33% to 0·41% C.)	7 17 6
„ Medium (0·42% to 0·60% C.)	8 10 0
„ Hard (0·61% to 0·85% C.)	9 0 0
„ „ (0·88% to 0·99% C.)	9 10 0
„ „ (over 0·99% C.)	10 0 0
Rails, Heavy, 500-ton lots, f.o.t.	9 10 0
„ Light, f.o.t.	8 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/9½ per lb. (nominal)	
Ferro-Tungsten	4/8 per lb. (nominal)	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 10 0	7/6
„ „ 6 p.c. to 8 p.c.	£23 5 0	7/6
„ „ 8 p.c. to 10 p.c.	£23 5 0	7/6
„ „ Max. 2 p.c. carbon	£36 0 0	11/-
„ „ „ 1 p.c. carbon	£38 5 0	11/-
„ „ „ 0·5 p.c. carbon	£41 0 0	12/-
„ „ „ carbon-free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£16 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 0 0 scale 6/- p.u.	
„ Vanadium	14/- per lb.	
„ Molybdenum	4/10 per lb. 5/- forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton	
Cobalt	8/6 to 8/9 per lb.	

NON-FERROUS METALS.

(*Official Prices, July 19th.*)

COPPER—	
Cash	£42 17 6 to £42 18 9
Three Months	£43 3 9 to £43 5 0
Electrolytic	£49 0 0 to £49 10 0
Best Selected Ingots, d/d Birmingham	£49 5 0
Sheets, Hot Rolled	£80 0 0

	Home.	Export.
Tubes, Solid Drawn (basis)	12¾d.	12¾d.
„ Brazed (basis)	12¾d.	12¾d.

BRASS—	
Ingots, 70/30, d/d Birmingham	£38 10 0

	Home.	Export.
Tubes, Solid Drawn 2/1 Alloy	11¼d.	11¼d.
„ Brazed	13¼d.	13¼d.

TIN—	
Cash	£229 17 6 to £230 0 0
Three Months	£225 2 6 to £225 5 0
SPELTER—	
Cash	£14 2 6 to £14 5 0
Three Months	£14 7 6 to £14 8 9
LEAD—	
Cash	£14 16 3 to £14 17 6
Three Months	£14 17 6 to £14 18 9
Aluminium Ingots (British)	£94 (net)

FUELS.

SCOTLAND

	Export.
LANARKSHIRE—	
(f.o.b. Grangemouth)—	
Navigation Unscreened	18/- to 18/6
Hamilton Ell	17/6
Splints	20/-
AYRSHIRE—	
(f.o.b. Ports)—	
Steam	17/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	18/-
Unscreened Navigation	18/6
LOTHIANS—	
(f.o.b. Leith)—	
Hartley Prime	18/-
Secondary Steam	16/9

ENGLAND

SOUTH YORKSHIRE, DONCASTER—	
Steam Hards	19/- to 20/-
Washed Smalls	16/- to 17/-
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	19/- to 19/6
„ Second	18/- to 18/6
„ Best Small	15/6
Unscreened	17/- to 18/-
DURHAM—	
Best Gas	19/6
Foundry Coke	26/- to 28/-

SOUTH WALES

CARDIFF—	
Steam Coals:	
Best Admiralty Large	23/6 to 24/-
Best Seconds	23/- to 23/6
Best Dry Large	23/- to 23/6
Ordinaries	23/-
Bunker Smalls	16/- to 17/6
Cargo Smalls	15/- to 15/6
Dry Nuts	27/6 to 28/-
Foundry Coke	35/- to 42/6
Furnace Coke	30/- to 33/6
Patent Fuel	25/6
SWANSEA—	
Anthracite Coals:	
Best Large	36/- to 38/-
Machine-made Cobbles	41/- to 45/6
Nuts	40/- to 45/-
Beans	33/- to 38/6
Peas	26/- to 30/-
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	22/6 to 24/6

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon; and 9d. per gallon on oil for road vehicles.

Ex Ocean Installation—	Per Gallon.
Furnace Oil (0·950 gravity)	3¾d
Diesel Oil	4¼d

French Engineering Notes

(From our own Correspondent in Paris)

Strategical Works

UNDERTAKINGS that are claimed to be of strategical, as well as of economic value can easily be made to arouse national interest by publicity given to them during periods when they are shown to meet national necessities. An attempt was made to boom the Trans-Saharan Railway at the International Colonial Exhibition in Paris some years ago, when influential groups behind the scheme presented a fully worked out plan for constructing and running a railway across the Sahara Desert, between Algeria and the Niger, with special wagons and coaches and oil-driven locomotives. Interest then died down, only to be revived by another intensive campaign in favour of the railway for its strategical value when the problem of national defence became paramount. In Parliament there is a strong minority support for the scheme, but nothing will be done until the Colonial Commission of the Senate has completed its inquiry into the strategical and economical possibilities of the proposed railway. The strategical value of the line is much discussed and severely criticised, particularly by motor car interests. This divergence of opinion will be settled by the military authorities, but the railway cannot be accepted solely for its strategical character, and the Commission's inquiry aims at ascertaining whether there is any real prospect of the railway obtaining sufficient freight from French West Africa to pay its way. Expert opinion is fairly unanimous on this point. Objections may be summarised by the evidence of Professor Chevalier, which appears to have made a strong impression on the Commission. Practically all the production of French West Africa is limited to a coastal belt about 250 miles wide, and behind it the country is poor, with an extremely sparse population and offers little promise of providing freight for a railway. Professor Chevalier doubts even whether the irrigation works in the Niger Valley will give anything like the results expected of them. He sees no hope of any real progress being made without a scientific investigation into the possibilities of these regions, and proposes the creation of a Sahara Scientific Institute to deal with the whole problem. A shorter, cheaper, and more useful railway could, he said, be built along a western route to develop a coastal belt. Another big scheme for which strategical advantages are claimed is the Canal des Deux Mers that has been revived from time to time during the past two centuries, and was brought up to date with plans that accompanied a demand for a concession presented to the Minister of Public Works eight years ago. This broad and deep waterway for big ships would follow the course of the Garonne for the greater part of the distance between Le Verdon on the Atlantic and the small port of La Nouvelle, to the south of Narbonne, on the Mediterranean. Recent publicity given to the scheme and attempts to finance it have drawn from the Minister of Finance a warning that no concession has been granted.

The Steel Situation

The state of things in the steel industry has changed since the period covered by the annual report of the Comité des Forges on the situation in 1938 when steel makers could find little that did not justify complaint. Large extensions and improvements to plants had been carried out at steel works with the object of increasing production and lowering costs, but most of the plants remained partly idle, and there appeared to be little hope of an early recovery that would bring some adequate return for the expenditure incurred. Consequently, the report of the Comité des Forges did not view the future with optimism. Fortunately, the past few months have seen a change for the better. The situation has become easier, with a more hopeful outlook, and a good volume of business came to mills and forges in anticipation of a rise in prices, which has recently been authorised by the control committee. There is plenty of work to carry mills and forges over the holiday period. Last year the period was limited to six weeks when industries closed down in different districts in rotation for a fortnight, and the releasing of workers during that short time caused considerable outside disorganisation from which workers themselves suffered. The holiday period has now been officially extended, and in many cases, still further lengthened by agreement between employers and men for spreading holidays over some months. Under the new arrangement, works can be carried on without interruption for another three months or so, with the prospect of additional business forthcoming for the needs of national defence, while there is promise of a general activity increasing the demand for steel. The chief matter for concern at the moment is a gradual and persistent inflation of living costs, and a consequent tendency towards higher prices of goods which would rise automatically if nothing were done to check them. Neither steel makers nor anyone else want prices to advance beyond an acceptable market level, if they can get reasonable profits by lowering production costs, which is now only possible by the State relieving industry of some of its taxation burdens.

Engineers' Responsibility

When the Government has to carry out an exceptionally difficult work of reorganisation, it places the responsibility for doing it on an engineer, who is entrusted with full authority. Companies depending more or less on State aid have been saved from disaster by engineers whom the Government put in charge of them, and it seems as if the Government will continue to follow this practice when taking advantage of its new prerogative to appoint managing directors in companies in which the State has a majority interest through payment of subsidies or for other reasons. The most conspicuous case of an engineer being appointed to undertake a heavy duty is that of Monsieur Surleau, who was transferred temporarily from the National Railway Company to Marseilles, which had fallen into a hopeless state of disorder and insolvency. This condition of affairs was revealed by the town's incapacity to deal with a fire that broke out in some stores in October last year, and had disastrous consequences with heavy loss of life. Monsieur Surleau has entire charge of all the municipal services, for the reorganisation of which he has full responsibility.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

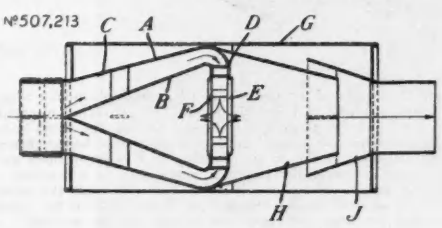
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES

507,213. December 9th, 1937.—SILENCERS, Joseph George Blanchard, 25, Redcliffe Square, London, S.W.10.

The silencer shown comprises a collision unit mounted within a vacuum chamber. The collision unit comprises hollow outer and inner members A and B respectively, of which the outer member has a frusto-conical portion C connected at its base to a portion D, which is defined chiefly by a surface of revolution formed by an arc revolving about the axis of the frustum. The portion D is formed with a central aperture E. The inner member B has a conical portion of base angle smaller than that of the frusto-conical portion C, and a portion somewhat similar to the portion D of the member A, and provided with a central aperture F of substantially the same size as the aperture E. The member B is mounted concentrically within A by means of lugs. In use, the outer member receives exhaust gases at its smaller end by way of an extension forming an inlet pipe. The gases envelope the inner member and traverse the annular path of varying cross-sectional dimensions formed between the two members to enter the cylindrical space or zone situated between the apertures E and F, where general collision occurs

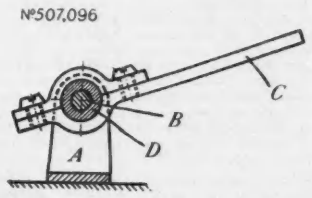


between gas particles converging upon the axis of the silencer from all sides as viewed along the axis. After collision gases may pass into the interior of the inner member by way of the aperture F and out through the aperture E of the outer member, the paths followed by the gases in passing in either direction forming figures of substantially conical or cylindrical shape co-axial with the axis of the collision zone. The interior of the inner member acts as a sort of cushioning chamber, and the majority of gases will pass, immediately after collision, through the aperture E. The vacuum chamber is formed by a casing G which surrounds and extends beyond the outlet end of the collision unit. A frusto-conical tube H, which is secured to the portion D of the member A, and, by lugs, to the casing, projects at its smaller end into the larger end of another frusto-conical tube J, and receives the gases which pass through the aperture E after collision. The tube J delivers the gases to an exit pipe, and the gases exert an injector effect upon the interior of the casing by way of the annular space between the tubes H and J, with the result that a vacuum is formed within the casing surrounding the collision unit, the silencing effect of the latter being thereby augmented.—*June 9th*, 1939.

SWITCHGEAR

507,096. February 10th, 1938.—BEARINGS FOR ELECTRIC SWITCHES AND CIRCUIT BREAKERS, Carl Weydemeyer, of 149, Hansaring, Cologne, Germany; Adam Kress, of 28, Viktoriastrasse, Cologne, Germany; and Matthias Zander, of 1, Aegidienbergstrasse, Cologne, Germany.

In electric switches, circuit breakers, and other electrical switching apparatus, there are parts which, when operated, have a swinging or rocking movement about a pivot or bearing, as, for example, the switch contact bridging member. The provision of a good bearing for these movable parts is a matter of some difficulty, because in operation the direction of rotation

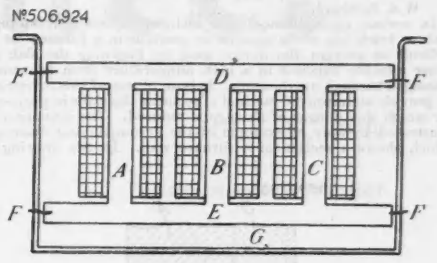


and the bearing pressure are constantly changing. Continual lubrication of the bearing is necessary, but only in rare cases is this possible, because the movable parts, especially in circuit breakers, are mostly situated in the least accessible positions and their care is often forgotten. In the example illustrated, the bearing bracket A carries the bearing axis pin B, which is made of metal, such as steel. The movable part of the switch device—for example, the lever C—carries fixed firmly thereto—for example, by means of a bridge piece having lugs and fastening screws—the bearing bush D consisting of non-metallic artificial resin material.—*June 9th*, 1939.

TRANSFORMERS AND CONVERTERS

506,924. December 6th, 1937.—ELECTRIC TRANSFORMERS, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2, and Bertie Withers, of 62, Fisher Avenue, Rugby.

This invention is particularly applicable to voltage transformers for directional earth leakage protection. The essential requirement of such transformers is that they should be able to transform the zero phase sequence component voltage as well as the positive and negative components. An ordinary three-leg, three-phase transformer will only transform accurately the latter two components, because for a zero phase sequence component there must be some additional path by which the unbalanced flux can return. In accordance with the invention, the core is constituted of three parallel wound limbs A B C joined by transverse portions D and E. The transverse portions are extended at F to co-operate with the wall of an enclosing tank G for the transformer, so that the wall of the tank constitutes an effective portion of outer unwound limbs of the transformer. By making the tank of suitable size the extended

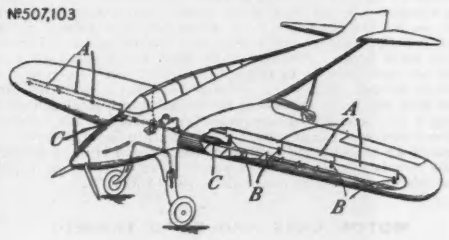


portions at F may be made to fit closely within the tank and the air gaps between the extended portions and the tank wall may be reduced to any desired extent.—*June 6th*, 1939.

AERONAUTICS

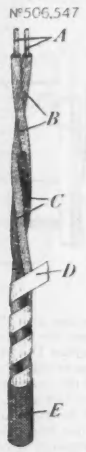
507,103. February 15th, 1938.—AIR BRAKE FOR AIRCRAFT, Fairey Aviation Company, Ltd., North Hyde Road, Hayes, Middlesex, and Flight-Lieutenant Louis Massey Hilton, "Links," Gordon Avenue, Stanmore, Middlesex.

As shown herewith a series of plates A is pivoted by links B to the front spar of the aircraft wing so that they may be raised and lowered by turning one of the links B about its pivot by



an hydraulic jack C to and from which the flow of fluid may be controlled by a valve actuated by a control lever which serves to control the flow of fluid to hydraulic jacks for actuating the undercarriage. The plates may be arranged end to end, as illustrated, or they may be in spatial arrangement, or they may be replaced by a single plate. In another form of the invention the plates may be raised against spring or gravity action by the inflation of an air tube beneath.—*June 9th*, 1939.

TRANSMISSION OF POWER

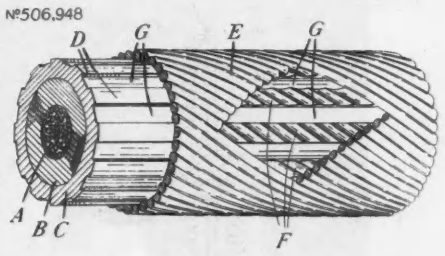


506,547. December 14th, 1937.—ELECTRIC CABLES, Norddeutsche Seekabelwerke Aktiengesellschaft, of Nordenham, Germany.

The object of this invention is to avoid moisture deposits in cables insulated with polystyrol. The spaces between the insulated conductors, or between such conductors and the fillers stranded therewith, are in direct communication with the outer air, in order to prevent moisture deposits. The strongly enamelled conductors A are wound with flexible threads B of polystyrol with a long laying length and are stranded together; filler cords C of polystyrol are stranded with the insulated conductors. A flexible band D of polystyrol is wound in open helical windings on the conductors and cords, and the iron wire braiding E is provided thereon.—*May 31st*, 1939.

506,948. March 28th, 1938.—ELECTRIC CABLES, Callender's Cable and Construction Company, Ltd., of Hamilton House, Victoria Embankment, London, E.C.4, and Jack Taylor, of the works of the company at Leigh, Lancashire.

A cable constructed in accordance with this invention comprises a stranded conductor A with an enclosing covering of insulation B and an extruded sheathing C of lead. The sheath C is formed with a number of outstanding longitudinal ribs D, equally spaced apart about the cable axis, and of substantially rectangular section. A layer E of armouring wires is subsequently applied tightly about the sheath C so that the wires



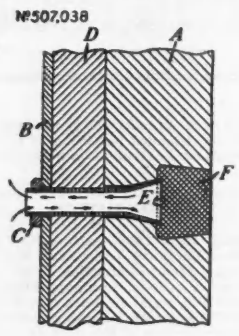
become embedded in the ribs D, thereby forming and occupying grooves F extending across the ribs in the direction of the lay of the armouring wires. If a coating of compound be applied to the lead sheath before the application of the armouring wires, the compound will accumulate in the spaces G between the ribs. Thus the wires whilst embedding themselves in the ribs will also sink partially into the spaces G, from which the excess compound will be forced out between the wires. The armouring wires thus become substantially immersed in the compound which serves to protect both sheath C and armouring E against corrosion.—*June 7th*, 1939.

FURNACES

507,038. October 12th, 1938.—METHOD OF SECURING IN POSITION THE PARTS OF THE LINING OF A HIGHLY HEATED SPACE, Sir Harold Edgar Yarrow, Scotstoun, Glasgow, W.4, Scotland.

In certain circumstances—for instance, where a refractory slab or brick has to be secured in position in a furnace—it is difficult to prevent the device used for fastening the slab or other member exposed to a high temperature from becoming damaged through overheating. It is an object of this invention to provide an improved method of securing the slabs in position, by which this danger of damage is reduced. The invention is illustrated by way of example in the accompanying drawing, which shows a section of a furnace wall. In the drawing a

№507,038



refractory slab A is secured to the steel casing B of the furnace by a hollow bolt and nut C which passes through the slab casing and an intermediate slab D of heat-insulating material. The bolt is hollow throughout its length and at one end E is formed with walls which taper outwardly from the shank and form the bolt head. Slots in the head are provided to permit the bolt to be held while a nut is screwed up tight. After the nut has been tightened the recess at the bolt head is filled with a plug F of a suitable plastic refractory material which hardens after insertion. The arrows in the drawing indicate the circulation of air through the bolt when the furnace is in operation. This circulating air serves to prevent the overheating of the bolt which occurs with solid bolts.—*June 8th*, 1939.

MOTOR CARS AND ROAD TRAFFIC

506,459. May 20th, 1938.—THROTTLE VALVE CONTROL DEVICES FOR INTERNAL COMBUSTION ENGINES, General Motors Corporation, Grand Boulevard, Detroit, Michigan, United States of America.

This invention relates to the control means for an internal combustion engine, of the kind in which a hydraulic column is used to transmit the movement of the accelerator pedal or manually applied lever to the throttle valve. It has been designed especially for use with such an engine installed on a motor vehicle. Referring to the drawing, the accelerator pedal A is connected to the stem of a diaphragm mounted in the closed

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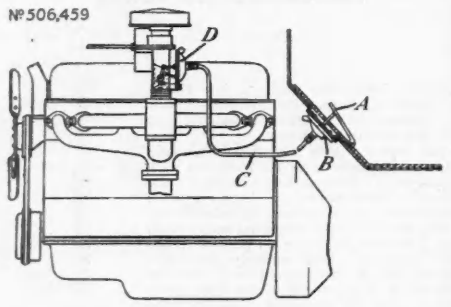

chamber B. The lower part of the diaphragm chamber is connected by a pipe C to the lower half of another diaphragm chamber D. A spindle from the diaphragm in D operates the throttle valve lever on the engine. The diaphragm chambers and the connecting pipe are filled with a suitable fluid so that when the accelerator pedal is pushed down the pressure exerted in B is transmitted to D to give a corresponding movement to the throttle lever. In order to eliminate any effect of contraction or expansion of the fluid on the throttle valve the diaphragm at the accelerator end is made slightly weaker than the other.—*May 30th*, 1939.

WELDING

506,886. October 13th, 1938.—ELECTRIC WELDING APPARATUS, Messerschmitt Aktiengesellschaft, of 118A, Haunstetterstrasse, Augsburg, Germany.

According to this invention, a sound or supersonic wave emitter is arranged closely adjacent to or within the welding electrode of an electric welding device. It has been found by

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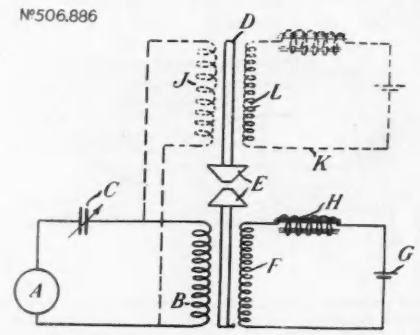

experiments that the qualities and the behaviour of light metals are substantially influenced by the action of sound or supersonic oscillations. Not only the static and dynamic strength but also the resistance to corrosion are substantially improved or modified in a favourable manner. The sound wave emitting arrangement comprises a generator A producing alternating current of sound or supersonic frequency. The generator is connected in series with an oscillation circuit comprising an inductance B and an adjustable condenser C. The coil B of the oscillation circuit is arranged coaxial with an associated nickel tube D carrying a copper electrode E. Inside the coil B a pre-magnetising coil F is arranged, which is likewise disposed coaxially with respect to the associated nickel tube and is connected to a battery G through a choke coil H. Thus the nickel tube, being of magneto-strictive material, oscillates mechanically at the frequency of the supply A. In the illustrated example, in which both welding electrodes are provided with arrangements for transmitting sound or supersonic frequencies, the inductance of the oscillation circuit is divided in two coils B and J, each of which is disposed coaxially with respect to the associated nickel tube. A second D.C. circuit K, similar to the first and comprising a magnetising coil L, serves for pre-magnetising the second nickel tube.—*June 6th*, 1939.

507,159. December 9th, 1937.—RODS FOR USE IN WELDING, The Sure-Arc Electrode Company, Ltd., and Frederick William Calow, all of Coronation House, Lloyds Avenue, London, E.C.3.

The object of this invention is to provide a flux-paste-covered or flux-dipped arc welding electrodes with a wrapping which will permit the electrode to be bent without undue rucking of the wrapping and which will also prevent the flux covering from flaking. The metal core A of the electrode is covered with a covering of flux B applied in the form of a paste which is moulded around the core by any suitable machine. The protective covering C applied to the exterior surface of the flux

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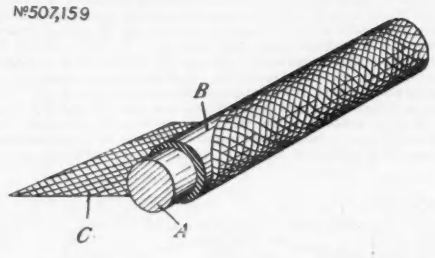

paste B consists of a narrow strip of open-mesh muslin which is wound tightly and spirally around the covering electrode so as completely to cover it from end to end, the mesh being sufficient both to permit the electrode to be bent without undue rucking of the fabric covering and to serve both as a protective covering for the flux paste and as a binding or knitting agent. Before use it is preferable to treat the fabric material so that during welding the destruction of the fabric covering by heat will not deleteriously affect welding. A protective covering according to the invention may either be applied spirally in a continuous length as shown, or in suitably cut lengths as wrapping.—*June 9th*, 1939.

MISCELLANEOUS

506,440. January 21st, 1938.—SOAKING PITS, Stein and Atkinson, Ltd., and James Stanley Atkinson, 47, Victoria Street, London, S.W.1.

The pit and the cover A are both circular and generally of usual construction, there being no central cover supporting column in the pit. The cover has mounted around its outer edge a series of rollers B which move on a circular runway at the top of the wall of the pit, the cover being supported solely by this means. The cover also carries at its outer edge, and within the line of rollers, a depending plate C, which moves in a trough containing sand, for example, so as to effect a seal. The cover has an aperture D extending from a point opposite the inner wall of the pit towards the centre. This aperture is closed by a lid constructed of brickwork in a metal framing in usual

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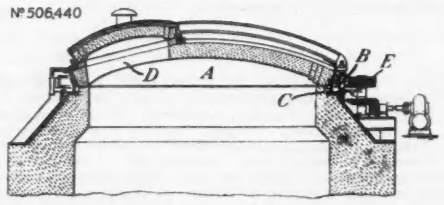

manner. It is provided with a sand or similar seal. The cover A is rotated by a toothed wheel E engaging a circular rack on its outer edge. The toothed wheel is driven through gearing from a motor. The soaking pit may be uncovered at any position desired, the aperture being sufficiently large to permit the removal or insertion of one or more ingots from or into the pit, while at the same time only the required portion of the pit is uncovered and heat loss is thereby reduced and detrimental cooling of the pit is prevented. In use, when it is desired to introduce or remove an article from the pit, the cover is rotated to bring the aperture over a point desired. The lid is then removed, the operation necessary is carried out, and the lid replaced. While the lid is removed only a small portion of the pit is uncovered.—*May 30th*, 1939.

506,555. February 3rd, 1938.—CLAMPS OR GLANDS FOR ELECTRIC CABLES, William Arthur Nelson, of 19, Elvan Street, Motherwell.

A cable clamp or gland according to this invention is constituted as a ring, preferably composed of mild steel, and flanges composed of U-shaped pieces of mild steel welded to the ring and adapted to receive the usual holding-down bolts in an associated junction box. The clamp or gland shown com-

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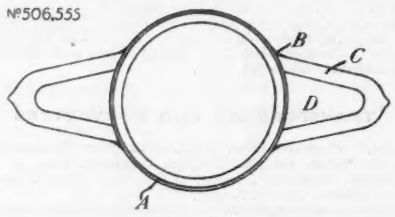

prises a ring A, preferably composed of mild steel. Welded at B to the ring are flanges composed of U-shaped pieces C of mild steel. The pieces C present at D apertures adapted to receive the usual holding-down bolts in an associated junction box or similar arrangement. In the use of the clamp or gland the ring is threaded on to the cable and is caused to abut against a flanged portion of the cable. The flanges are applied to the holding-down bolts and the nuts are applied to the bolts in the usual way.—*May 31st*, 1939.

506,089. March 15th, 1938.—FRICTION BRAKES, *Maybach-motorenbau Gesellschaft mit beschränkter Haftung, Friedrichshafen, Bodensee, Germany*; William John Tennant, 111–112, Hatton Garden, London, E.C.1.

The brake device described in this invention is designed particularly for accelerating the gear-changing operation in change-speed gears of motor vehicles. It is intended to provide a space-saving construction, a uniform application of braking surfaces, and an automatic, good equalisation of the forces applied to the brake parts. Journalled in the wall A of a gear casing is a gear wheel B and acting upon its inner periphery C

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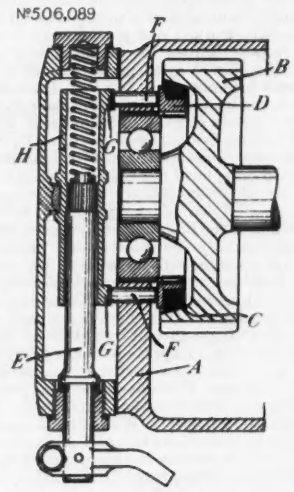

is the lining of a brake ring D. Adjoining the wall is a cover, in which is journalled the operating spindle E of the parts moving the brake surface. The pins F bear against cams G on a sleeve H provided with internal teeth in its central portion, which forms a driving socket for the correspondingly toothed upper end of the spindle. Sufficient clearance is provided between the engaging toothed portions to allow the sleeve to oscillate slightly upon its central part-spherical bearing. The cams are so designed that upon turning of the cam sleeve by the actuating lever the brake ring is pressed by the pins against the inner periphery of the gear wheel.—*May 23rd*, 1939.

507,031. June 14th, 1938.—COMBINED HOISTING, TRANSPORTING, AND WEIGHING MACHINES, John Sigfrid Grafström, Gibraltargatan 20, Göteborg, Sweden.

The apparatus described comprises a crane girder A, the wheels of which run on rails. The carriage B with wheels is provided with a weighing apparatus comprising weighing mechanism C of known design with a movable weight-graduated

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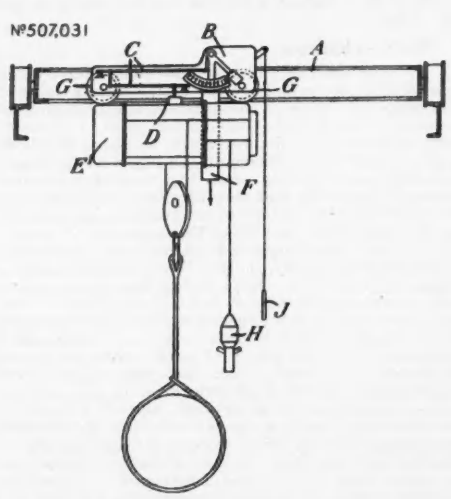

scale and suspension bar D for a motor hoist E, and a downwardly directed periscope arrangement F. The carriage rests on the girder A with the wheels G fitted into the cross beams of the girder. The load is hung in slings which are suspended from the hook of the motor hoist. The hoist is provided with a contact button apparatus H, and the weighing apparatus has an arrangement J for putting the weighing apparatus out of operation, operated by a hand chain.—*June 8th*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

British Waterworks Association

Tuesday to Saturday, July 25th to 29th.—Summer meeting at Nottingham.

PERSONAL AND BUSINESS ANNOUNCEMENTS

CONCRETE, Ltd., of Leeds and London, announce that an office and factory have been opened in Birmingham to deal with local inquiries. The office is at 3 New Street, Birmingham.